SCIENTIFIC AGRICULTURE

Vol. 23 DECEMBER, 1942 No. 4

PROBLEMS OF LAND SETTLEMENT IN SASKATCHEWAN[1]

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The earliest settlements within the present boundaries of the Province of Saskatchewan were located in the forested area, or along its margins. They were associated with the trading posts and forts established by the fur trade. During this period such attempts as were made to cultivate the land appear to have been frowned upon by the fur companies, although garden patches were tilled, and their productiveness is amply vouched for by reports of early travellers and explorers (1). Towards the end of the period of the great fur trade in the Hudson's Bay territory (about 1870) the settlements of Prince Albert, Batoche and Willowbunch were begun, and these were to some extent supported by agriculture, but more especially so after the disappearance of the buffalo about 1880. The first important agricultural development awaited the building of the Canadian Pacific railway and following its construction, settlement and development went forward at a rapid rate (6).

The rush to the open and easily broken lands of the prairies reached full flood in the early years of the century. By 1910 most of the good land had been settled, and by 1920 the prairie and park belt lands were fully occupied.

The period from 1920 to 1930 was a period of consolidation and development. Much new land was cleared and broken, new roads and railways were built and altogether this period was a prosperous one in Saskatchewan. During this decade there was to be sure a slow advance of settlement into the fringe of the forest, and districts such as Loon Lake, Meadow Lake and Porcupine plains were opened up, although at that time they were far from a railway line. However, the glamorous days of the land rush were past, and the period of "easy" settlement of lands had come to an end. Between the years 1901 and 1931 the cultivated acreage had increased approximately by fifty times, or from about 600,000 to 30,000,000 acres and the population by ten times or from about 90,000 to 900,000 (4).

Beginning with the year 1931 there occurred a series of years in which all the direst prophecies of those who had opposed settlement of the drier prairie seemed about to be fulfilled. Crop failures followed in a succession of drought years and the bare blown soil seemed to mock at the efforts and progress men had made towards the conquest of the plains. Crop losses and soil destruction were most severe on the poorer lands, but even on the best lands, yields were low, and soil drifting a serious menace.

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[1] Contribution from the Soils Department, University of Saskatchewan, Saskatoon, Sask. Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting, Olds, Alberta. June 18–19, 1942.

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It was inevitable that in the rush of settlement, poor land as well as good should be brought under cultivation. Many of the unfortunate farmers who largely by a matter of chance had settled on poor soils, came to realize the hopelessness of their situation as drought and soil drifting devastated their land. So a new trek of land seekers began. This time it was not a trek of hopeful, enthusiastic newcomers seeking a home in a new land, but rather a flight of disappointed and to some extent dispirited people seeking to escape from what appeared to be literally an advance of the desert over their homesteads. There was only one direction they could take in looking for land in Saskatchewan, and that was toward the north. Unfortunately, these settlers had little knowledge of the forest land of the north, and obtained little guidance in selecting new farms, particularly in the earlier period of the migration. It was soon apparent that another land problem had arisen, this time in the north, and it became necessary to set up a special branch of the Department of Municipal Affairs to handle the problem. The Northern Settlers Re-establishment Branch was therefore formed for this purpose in 1935 and immediately took over the administration and supervision of the affairs of about 6,000 settlers. The population of the area placed under the Northern Settlers Re-establishment Branch increased from 53,000 in 1926 to 114,000 in 1936, or by over 100%, while the increase over the Province as a whole in the same period was less than 15% (2).

SETTLEMENT PROBLEMS IN THE GRAY WOODED SOIL ZONE

The total area of Saskatchewan is given as 251,700 square miles of which about 243,000 square miles is land surface, or roughly 155 million acres.

The extent of the various soil zones is approximately as follows:

Brown soil	20 million acres
Dark brown soil	18.5
Black and degraded black	19.0
Gray wooded (podzolic)	31
Total	88.5

The remaining 65 million acres represent the approximate area of the pre-Cambrian shield much of which consists of rock outcrops. Considering the prairie area as a whole (brown, dark brown, and black soils) almost 50% of the land, or about 29 million acres is fit for cultivation. At the present time probably over 30 million acres are under cultivation in this area, but undoubtedly some further acreage of unfit land will be retired from arable use. The arability of the forested area is much lower than that of the prairie area. Nearly one-third of the land is muskeg, and much of it is sandy or rough and stony. It is doubtful if 10% of the gray wooded soil zone will prove fit for arable use. This indicates a maximum of 3 million acres of land fit for cultivation in the great area lying between the southern border of the forest and the southern limits of the hard rock exposures. Most of this arable land is likely to be found in the area adjacent to the black soil zone.

This is the only part of the province in which any considerable area of land remains that may be used for settlement, disregarding the possibility of developing large irrigation schemes.

The problems of the settler on a farm in the wooded area are quite different from those of the prairie. These problems revolve around the factors of soil fertility, cost of clearing, climatic environment, and conservation and utilization of the land resources.

Soil Fertility

The gray wooded soils are much lower in natural fertility than prairie soils. Not only are they more likely to be deficient in certain nutrient elements, but it is also more difficult to bring them into a good, friable physical condition. Furthermore, a proportion of the land brought under cultivation is likely to be peaty, and such land requires somewhat different cultural treatment than does the mineral soil.

Clearing

The task of clearing and breaking the land is far more difficult in the forest area than on the prairies. The cost of clearing, or labour required, is generally underestimated. Progress in breaking land is consequently slow, and many settlers become discouraged before sufficient land has been broken to provide a living. In many cases only ten or fifteen acres are under cultivation after a period of five years residence on the farm. Further more, the land is frequently stony, and this additional problem of clearing is also encountered. The amount of stone is difficult to assess in wooded country previous to clearing away the trees and brush.

Climate

The climatic environment of the forest area is quite different from that of the prairie. Early fall and late spring frosts are likely to be more severe, the summers cooler and shorter, and the winters longer and colder. Moisture conditions are, however, more favourable and less liable to wide fluctuations as between seasons. The cropping system and cultural practices must be adapted to the climate as well as to the needs of the soil, and must therefore be considerably different from those practised on the prairie. Even the weed problem is different, and the methods and work required in weed control differ greatly from the practices used on the plains.

Conservation and Land Use

On the prairie, farm waste land is typically grassland, and most uncultivated land is utilizable for grazing purposes. In the north, vacant or uncultivated land is naturally covered by trees and brush, with very little grass. Such land offers little in the way of grazing, but the trees nevertheless are of significant value if properly preserved and utilized. Indeed, the conservation of the forest appears essential to the proper economic utilization of the lands in the north. The loss of forest resources through uncontrolled fires is a matter for serious consideration. A prairie fire does not long affect the value of the prairie for grazing, but a timber fire has lasting effects on the value of the forest area.

In developing a policy towards the use of land in the forest area it would be false economy if thousands of acres of timber should be destroyed in order that a few acres of land might be brought under cultivation. It

should be pointed out once again that probably less than 10% of the area is fit for cultivation, and that such agricultural development as may yet take place will apparently consist of a scattered patchwork of agricultural settlements in a great forest area. The forest and its products should serve as an additional source of income to the settler. There are some further practical relationships between farms and forest requiring consideration. Streams rise in the marshes and springs of the green forest. Such streams may water farm lands and maintain the levels of the lakes. Incidentally the lakes and streams provide a necessary feature of the natural surroundings required by the wild life of the forest, and the area is thereby rendered more attractive to the trapper, fisherman or holiday seeker. These are all in addition to the value of the forest as a source of lumber, fuel, logs or posts.

INFORMATION WHICH SHOULD BE OBTAINED PRIOR TO SETTLEMENT

The first information required is relative to soil conditions. A broad reconnaissance survey might first be made in order to discover and delineate suitable areas. The minimum area worthy of consideration for settlement purposes would vary with accessibility, but probably should be sufficient to sustain at least a dozen or fifteen families.

In some areas more accurate base maps would be highly desirable before attempting a broad reconnaissance survey. Aerial photographs would be very helpful for both the broad reconnaissance and later for more detailed surveys of likely areas.

When a suitable area is discovered a land survey would be necessary in order to provide control points and cut lines for a more detailed soil survey.

Coincident with the soil survey there should be carried out a survey of forest and wild life resources. Such surveys should not only cover the proposed settlement area but also areas adjacent to and utilizable by the settlers. The best guarantee of forest conservation might be attained by acquainting the settlers with the value of forest resources, and by giving them an opportunity to share in the income obtainable when they are properly developed.

The information gained by farm management surveys in the pioneer fringe should be fully utilized in considering such economic factors as cost of clearing, establishing homes, size of farm unit and kind of unit required, and particularly the amount of land which should be cleared and broken. Preliminary studies (3) indicate that the cultivated land must reach about 70 acres before the farm is self supporting. Clearing and breaking land for the settler appears to be a good and sound investment. The work can be done much cheaper and more rapidly by using heavy machinery, and the land must be broken before it will produce the means for a living, and for the development of a community. Few settlers can afford the cost of clearing and breaking, and to many the discouragement of the task undertaken by their own hand proves fatal to their enterprise.

Since meteorological records are insufficient in the north it would be advisable to establish stations at suitable locations in the area. Information as to the length of the growing season is of particular importance.

Similarly new experimental sub-stations would be desirable in order to carry on investigational work in crops and cropping practice, including fruits and vegetables, the use of fertilizers in the maintenance and improvement of fertility, and in establishing a live stock program suitable to the area.

Finally the whole question of agricultural settlement in the north should be placed in proper perspective and relationship to the larger problem of the conservation of natural resources including soil, forests, water, wild life, minerals, and all public domain. There can be little excuse for the waste or destruction of any natural resource, and there is none whatever for haphazard and ill considered settlement schemes in the present state of our knowledge and experience. The amount of land suitable for settlement is limited, and much of the land available will be required by people already domiciled in the Province.

Any plans made for future land settlement, or for the re-establishment of people on the land, should leave no reasonable cause for doubt as to the opportunity for the success of the settler.

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POSSIBILITIES FOR SETTLEMENT ON IRRIGATED LANDS IN ALBERTA[1]

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Consideration of land settlement usually involves three factors: first, the number of settlers that can be accommodated; second, the desirability of the area for settlement; and third, the preparation needed before the land can be settled.

NUMBER OF SETTLERS

The number of settlers that can be accommodated on irrigated lands of Alberta depends largely on new irrigation developments. At present 508,000 acres are under irrigation in Alberta. This is divided into 4,379 farms averaging 116 irrigable acres per farm. This indicates that this land is quite well occupied. Actually an economic survey has shown only 56 farms that would be considered as available for settlers in 1939. Undoubtedly some people will find homes on the present irrigated lands as more intensive farming develops, but under existing conditions very few can expect to secure homes on the lands now under irrigation.

However, there are definite opportunities for increasing the irrigable area in Alberta. Reconnaissance or more detailed surveys already have been made of almost the entire area and these show that a possible 1,477,000 acres of Alberta lands still could be brought under irrigation at a reasonable cost.

Of the 1,477,000 acres susceptible to irrigation, about 1,000,000 acres may be considered as desirable from the standpoint of topography, soil, and climate. These lands would probably be the first to be developed.

One hundred and twenty irrigable acres per family seems to be a fair-sized unit for economic and crop conditions as they have existed in recent years in this territory. Some of the more desirable lands will support a more dense population while other localities would require larger holdings. If 120 irrigable acres were considered advisable per family, then this one million acres of land would furnish homes for 8,333 families. If these families average 5 per family, this would mean a possible farm population of 41,665.

The number of people who will settle on an irrigation project is not limited to those owning farms as there are the town residents who are supported from the farming enterprise of the district and farm labourers who must be considered as part of the land settlement. This is illustrated very well on the Lethbridge Northern Irrigation District. In that district there are approximately 800 farms with an estimated population supported by the district of 10,000 people on the farms, in the towns, and in the city of Lethbridge. This would indicate a population of 4,000 actually comprising farm families and that farm families comprise about two-fifths of the population supported by the irrigated lands of the district.

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[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting at Olds, Alberta, June 18–19, 1942.

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The Lethbridge Northern is just approaching what might be considered as an example of what should be expected in any district after a few years of development. It might be more nearly correct for most projects to consider the ratio of farm family population to those not living on farms but supported by the project as 1 : 1 instead of 2 : 3 as indicated on the Lethbridge Northern. On this basis 1,000,000 acres of new irrigation development in Alberta might support a total of 83,330 people after the projects had got well under way. The length of time that this would take would depend largely on the rate of influx of settlers and the type of development that was fostered by those responsible for the settlement.

The rate at which settlers could be accommodated is another factor. If a large influx of people comes into the country, it might be advisable to develop projects and settle them very rapidly. However, if conditions were as they have been during the past 25 years, development of projects and settlement would be quite slow. The report of the St. Mary's and Milk River Water Development Committee, recently submitted to the Dominion Government, is based on this slower development. They recommend a period of 5 years for developing the first 94,000 acres of a total of 345,000 acres of additional lands to be irrigated from these rivers, and that a period of 14 years be utilized in bringing the entire acreage under water. If this method is followed, it is evident that the irrigated lands of Alberta would not become an extremely important factor in handling after war settlement problems. However, the Committee makes the observation that the rate of development might be greatly accelerated should conditions warrant. If only the development recommended in the Committee's report be followed, about 783 families could be accommodated with a possible total population supported by this new development of 7,830 people in the first 5 years. However, it is well to keep in mind that the irrigable lands in Alberta have a potential settlement possibility of over 80,000 people.

INDUSTRIAL DEVELOPMENT

Another factor that influences the population that can be supported is that certain industries frequently develop in irrigated areas. This especially is true of food processing plants. The reason for this is that the quantity and quality of crops fluctuates but little on irrigated farms in a dry area that is comparatively free from frost hazards. This makes it possible to depend on a uniform supply of raw material. The successful beet sugar and vegetable canning factories, alfalfa meal plants, and cheese factories already established in Southern Alberta, are an illustration of this situation.

Also future irrigation development in Alberta will furnish opportunity for power production which should tend to encourage industries to locate in the area.

THE DESIRABILITY OF THE AREA FOR SETTLEMENT

Most of the lands of Alberta, for which irrigation has been planned, may be considered as definitely desirable for settlement. Construction costs are not excessively high, climatic conditions are quite satisfactory, and soil and topography features, generally, are good.

Climate

Except for the north end of the North Saskatchewan Project, the climate can be considered as desirable for irrigation farming. In fact, the dry nature of the climate of this area is one of its valuable assets for irrigation farming, and the absence of late spring, summer, and early fall frosts, makes it possible to grow quite a range of crops.

It would seem that we know enough about the climatic conditions to state that all of the district south of the Goose Lake line of the C.N.R., where irrigation projects are proposed, is suitable for the production of such crops as sugar beets and canning crops. Stated in the parlance of the irrigation farmer, these areas range from a two-crop to a three-crop alfalfa climate. Most of the 345,000 acres that come within the proposed Lethbridge Southeastern Project, have a climate about equal to that of Taber, a district that has been proved to be very well suited for the production of a variety of truck crops. Incidentally, southern Alberta is one of the best sugar beet areas in North America.

Topography

Most of the land selected for irrigation is level enough to be considered as fairly desirable for the purpose. Some land levelling will be required before all the lands can be settled but this has been provided for in the estimates made by the St. Mary's and Milk River Water Development Committee for that area and would likely be made a part of the construction costs of any project.

Soils

Most of the soils in these projects can be considered as satisfactory for irrigation purposes. There are but small areas of problem soils. In this regard it should be kept in mind that light soils are highly desirable for irrigation farming, especially for alfalfa, sugar beets, canning crops, and heat loving crops such as cantaloupe and melon. The extremely fine clays are the least desirable but they can be utilized. Some alkali troubles likely will develop but no great difficulty is expected from this source except in the northern part of the project north of the Red Deer river.

Water Supply

Provision has been made for a sufficient water supply for all of the projects so far proposed. The legal duty of water of 1.5 acre feet per acre per year has proved to be ample in the district so far irrigated. Sufficient allowance also has been made for storage and transmission losses.

The Possibilities for Home Building

Perhaps the most desirable feature is the opportunity the irrigated farm supplies for satisfactory home building. All of our irrigation experience in Alberta indicates that farmers can and do make good homes on their irrigated farms. Further than this, a large proportion of them eventually establish themselves economically. Progress is slow, and in the past, failures have been quite high but eventually irrigation projects become populated with economically stable citizens. One important consideration is that the farmer can be assured of raising all the vegetables needed for his family and the feed required for stock, the first year of settlement and every year thereafter.

Supervision of Settlers

One valuable asset that exists in Southern Alberta for irrigation settlement is a population experienced in irrigation farming in that district. This is extremely important and may go far to avoid many of the mistakes and difficulties that have been encountered in the development of irrigation projects in the past. All of the early settlement in Alberta was with people who knew practically nothing about irrigation farming as it applies to Alberta. Even those who had been accustomed to irrigation in other countries found conditions so entirely different here that their previous experience was of but minor use to them. In fact in many ways it was a hindrance as they attempted to use farm practices to which they had been accustomed and which frequently were not applicable at all to our conditions.

Now, however, those who have had experience on the half million acres of irrigated lands already developed, have made much progress in their learning, while in the past even the agricultural advisors were working in the dark. Now many well trained advisors can be secured and hundreds of young farmers who have grown up on Alberta irrigated lands are available to scatter among the newcomers. Actually this may be, and is likely to prove, one of the more valuable assets in our future irrigation development. The policy adopted at Rolling Hills in the Eastern Irrigation District of placing farmers with local irrigation experience on a quarter section on practically every section of land is bearing desirable fruit where the farmers on the other lands were all from dry areas in Saskatchewan and so had no previous irrigation experience. It does not seem unreasonable to expect that our future irrigation development in Western Canada will be much less difficult than has been experienced in the past.

PREPARATION NEEDED BEFORE THE LAND CAN BE SETTLED

Obviously the first requirement for the preparation of these lands for irrigation farming is the construction of the irrigation works. This is costly and requires time. The estimated costs for actually constructing the reservoirs, diversion dams, various structures, and canals for the Lethbridge Southeastern Project, which has been determined in some detail, is $43.99 per irrigated acre. This includes $3.00 per acre for land preparation, $1.00 per acre for colonization, 60 cts. per acre for agricultural services and $2.54 per acre for operation and maintenance deficit during the development period. All of these estimates are based on pre-war conditions and would have to be modified to meet situations that exist at the time of the development. In the past no provision has been made for land preparation, colonization or agricultural services in the estimates of the cost of the project. This is one of the mistakes that should not be repeated. Another is that the public at large, which of course means governmental agencies, should bear a large portion of the construction costs. This will not be discussed further here as the principle has become so widely accepted.

As to engineering features of these projects, fortunately they are not difficult.

In conclusion we may state that 1,477,000 acres of land are considered as being irrigable in Alberta, south of the north boundary of Township 34. One million acres of this may be considered as satisfactory for intensive irrigation farming. These million acres should supply homes for at least 8,333 families and should support a total population of about 80,000 people. Soil, topography, and climate are satisfactory and water supplies seem to be adequate. Therefore, it would seem that satisfactory permanent settlement can be looked for on these lands and the prosperous communities now existent on the irrigated lands of Southern Alberta may be increased about two-fold.

ACKNOWLEDGMENT

In the preparation of this paper, free use has been made of the report of the St. Mary's and Milk River Water Development Committee and P.F.R.A. reports.

SOME AVAILABLE DATA RELATING TO LAND SETTLEMENT IN ALBERTA[1]

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The principal farmed portion of Alberta lies roughly within a rectangle extending from the southeast corner of the province to a point about 50 miles northwest of Edmonton. In this area settlement began in the 'seventies and was practically complete by 1915. In general, it is the prairie and parkland portion of the province and is composed of brown, dark brown, shallow black, black, and black-gray transition soils. It totals about 40 million acres. If the Peace River area (which contains some black and transition soils) be added to the above described area, the bulk of Alberta's farmed land will be included. This leaves over 100 million acres in the wooded or podsolic soil zone of Alberta, only a small percentage of which is at present cultivated.

A reconnaissance soil survey (traverses every mile) has now been made of all of the brown soil zone, nearly all of the dark brown zone, but only a relatively small percentage of the shallow black, black, and transition soil zones. A broad reconnaissance survey has been made of a portion of the wooded soil zone, principally in the Peace River area.

The object of this paper is to give a brief summary of the data collected to date by the Alberta Soil Survey, P.F.R.A., and the Soils Department at the University of Alberta on the acreage of pasture and arable land in those portions of the province covered by a soil survey. Some comparisons with 1936 census data will be made.

BROWN SOIL ZONE

The brown soil zone in Alberta, the semi-arid or bald prairie section of the province, occupies approximately 12,500,000 acres. Although well within Palliser's triangle and often spoken of as "the land that should be given back to the buffalo", it has to date produced a large total amount of agricultural products—principaIly wheat and beef. Agriculture in this area dates back to the 'seventies, with the coming of ranchers to the Medicine Hat district. Grain growing on a large scale in this zone did not begin until about 1912. At this time land seekers, ranging from the humble homesteader with an ox-team to the syndicate with a steam engine, were attracted by the large open stretches of prairie land, needing only to be turned over to produce wheat. This land boom was encouraged by the favourable cycle of years preceding 1919, and during that period millions of bushels of wheat were produced in this semi-arid soil zone. What happened from then on is history, some of which does not make pleasant reading. However, when we are preparing the balance sheet for this area, credit from a national viewpoint must be given to the large total of agricultural products that has come from within its boundaries.

[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting, Olds, Alberta, June 18–19, 1942.

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To aid in any appraisal of the future use of the brown soil zone, it is necessary to know something of the climate of the area. Climate over a long period of years is a principal soil forming factor and is, in this area, the principal limiting factor in crop production. We must assume that the long term average climate of the past is the climate that must be reckoned with in the future. The average annual rainfall is from 11.5 to 13.5 inches, with a fairly high evaporation rate; the summer evaporation at Manyberries for the last 10-year period (slightly drier than average) exceeds annual rainfall by nearly 3 to 1. The average yearly temperature is 42.9 degrees F. and the average April to July (inclusive) temperature is 56 degrees F. The average frost-free period is from 120 to 130 days or, if 29 degrees F. rather than 32 degrees F. is taken as the lower limit, it is from 135 to 145 days. This is a relatively long frost-free period, and is a beneficial factor in determining the kind of crops that can be grown. It is particularly significant in irrigation farming.

A closer study of rainfall data from this area reveals certain important facts. Fortunately between 75 and 80% of the total annual rainfall comes during the effective period (previous fall and growing season). Of this rainfall, however, not all is effective. Approximately 15 % comes in individual rains of less than 0.2 inch, most of which is lost by evaporation before it reaches the plant roots, and 50 per cent comes in rains of over 0.5 inch in 24 hours, some of which is lost by run-off. On the average, then, this area is very close to the drought border line. There is, however, considerable yearly variation in total rainfall. During the last 50 years at Medicine Hat this variation has been from about 6 to 26 inches. If 9 inches of previous fall and growing season precipitation be considered the border line in this zone between those years that are drought years and those that are not, then approximately one-half of the years during the last 50 years have been drought years. It should be stated here that this arbitrary border line is affected by soil conditions and also by other climatic factors.

Under climatic conditions such as this, it is safe to say that only the best soil types can be considered as arable land; that is, a major portion of the area must best be used as permanent native pasture.

Compilations from the 1936 census returns show that of the 12,500,000 acres in the brown soil zone 7,500,000 acres or 60% is occupied by farmers, and that 2,700,000 acres or 21% is cultivated. (There are well over 500,000 acres of abandoned land in this area.) Of the cultivated land, 48%, or 1,300,000 acres, was in wheat. Since the common practice in this area is a two-year rotation, wheat makes up practically the entire crop. In this area there are slightly over 9,000 farm operators, with 1,800 or 19% tenants. Farms here are large, there being 1,500 farms 1 to 300 acres in size, 3,300 between 300 and 639, and 4,400 over 640 acres. The above figures are for dry land, that is, they are exclusive of the 450,000 acres under the irrigation ditch (225,000 of which are irrigated).

The entire brown soil zone has been covered by the Alberta Soil Survey—part of it by the Department of Soils in 1922 to 1926, and part by the P.F.R.A. survey since 1936. The area in the various land classes in the Zone has been calculated from these surveys as shown in Table I.

TABLE 1.—LAND CLASSES IN THE BROWN SOIL ZONE

Class	Acreage	Approximate Production Capacity
1. Poor to fair pasture	1,300,000	Over 40 acres per head
2. Fair to good pasture	4,300,000	20–40 acres per head
3. Good to excellent pasture	1,000	Under 20 acres per head
Total pasture (acres)	5,601,000 or 47%	
4. Poor to fair arable	4,300,000	Less than 10 bu. wheat per acre
Total marginal (acres)	4,300,000 or 36%	
5. Fair to fairly good arable	2,000,000	10–15 bu. wheat per ac.
6. Fairly good to good arable	80,000	15–20 bu. wheat per ac.
Total arable (acres)	2,080,000 or 17%	

Comparing this figure of 2,080,000 acres of fair or better arable land with the 2,700,000 at present cultivated, it seems reasonable to suggest that at least all available land in this zone is at present cultivated.

The 4,300,000 acres of poor to fair arable land is not good soil for dry land farming and certainly with the present production, should not be considered as wheat land. Much of it is of a type that under very favourable climatic conditions will grow a good grain crop, but the records show that these very favourable years are far apart.

Assuming that 400 acres of arable land is the minimum needed in this zone for a farm unit (this would need to be supplemented with pasture land), then there are 5,000 such units in the area. The census of 1936 reported over 9,000 operators. Not all, however, of these 9,000 would be "average" farmers.

The above comparisons are presented to show that it would appear from what data are available that the brown soil zone of Alberta has, for the present at least, sufficient farmers and a maximum of cultivated dry land.

DARK BROWN SOIL ZONE

The dark brown soil zone comprises 8,500,000 acres lying as a band about 50 miles wide adjacent to the brown soil zone. That is, it is a transition zone between the brown zone to the southeast and the black zone to the north and west. Most of this area was settled between 1905 and 1910, although it possibly was not plowed up as rapidly as was the land in the brown zone. There is considerable abandoned land in this area but not as much as in the brown zone.

The climate in the dark brown zone is somewhat more favourable for crop production than in the brown zone. The average annual rainfall is between 14 and 16 inches, with a seasonal distribution similar to the

brown zone. There is less total rainfall in the north portion of the dark brown zone, but a lower evaporation than in the south. The number of drought years is lower than in the brown zone—about 1 in 3 or 4.

Compilations from the 1936 census returns show that, of the 8,500,000 acres, 74% or 6,300,000 acres are occupied by farmers, and that 45% or 3,800,000 acres are cultivated. This is a much higher percentage cultivated than in the brown zone, viz., 45% as compared to 21%. Of this cultivated area 2,000,000 acres or 53% was in wheat. This indicates that here also wheat has been the major crop.

There are 12,000 farm operators in this zone with 3,000 or 25% tenants. The farms are divided as follows: 2,300 between 1 and 300 acres, 5,500 between 300 and 639, and 4,200 greater than 640 acres. These refer to dry land; there are 400,000 acres under the irrigation ditch with about 250,000 acres irrigated.

This zone, with the exception of about 500,000 acres, has been covered by a soil survey, and the area in the various land classes has been calculated as shown in Table 2.

TABLE 2.—LAND CLASSES IN THE DARK BROWN SOIL ZONE

1. Poor to fair pasture	400,000 ac.
2. Fair to good pasture	1,700,000 ac.
3. Good to excellent pasture	300,000 ac.
Total pasture	2,400,000 ac. or 30%
4. Poor to fair arable	1,500,000 ac.
Total marginal	1,500,000 ac. or 18.5%
5. Fair to fairly good arable	2,300,000 ac.
6. Fairly good to good arable	1,700,000 ac.
7. Good to very good arable	200,000 ac. (20–25 bu. wheat per ac.)
Total arable	4,200,000 ac. or 51%

Comparing this figure of 4,200,000 acres of fair or better arable land with the 3,800,000 acres at present cultivated, there appears to be a little arable land still left to be cultivated. Some of the poor to fair arable land in this zone might under special management be considered as arable.

If the arable land of this zone be divided by 400 as a minimum arable unit (there is less pasture land available in this than in the brown zone), it gives 12,000. The census of 1936 gave 12,000 farm operators in this zone.

SHALLOW BLACK, BLACK, AND TRANSITION ZONES

In this area is grouped the soil lying between the dark brown zone and the wooded or podsolic soil zone. It roughly forms a triangle in which lie the towns of Lloydminster, Edmonton, Calgary and Cardston. The main settlement of this area occurred between 1895 and 1910.

The climate of this area is much more favourable for crop production than is the climate of the dark brown or brown zones. The average annual rainfall is from 16½ to 19 inches. Over most of the area the summer evaporation rate is about 1 to 1, as compared to 3 to 1 in the brown soil zone. Drought years, years in which the total previous fall and growing season moisture is less than between 8 to 9 inches, are relatively few, averaging about one year in ten. The frost-free period in these zones is, however, much shorter than in the brown zone, namely about 100 days, or taking 29 degrees F. as the lower limit, about 115 days.

This area totals about 17,000,000 acres. Of this, about 16,500,000 acres or 91% is occupied, and 8,700,000 acres or 51% is cultivated. Of the cultivated acres about 3,300,000 acres were in wheat in 1936.

In this zone there were 48,500 operators in 1936 of which 8,500 or 18% were tenants. There are 25,000 farms between 1 and 300 acres, 18,000 between 300 and 639 acres, and 5,500 over 640 acres. That is, the average size of farm unit is much smaller than in the brown or the dark brown soil zone.

The Alberta soil survey has mapped only a portion of this zone, too small a portion to make any comparisons. However, in the areas that have been surveyed there is more land classed as arable than is at present being cultivated.

PEACE RIVER AREA

The P.F.R.A. soil survey have not worked in the Peace River area. However, 9,000,000 acres were covered by a broad reconnaissance soil survey between 1928 and 1931. Within this area there are 2,400,000 acres occupied and 650,000 acres or only 7% cultivated. There are 8,800 farmers with 800 or 8% tenants. The farms of this area are divided as follows: 5,250 farms between 1 and 300 acres, 3,050 farms between 300, and 639 acres, and 575 farms over 640 acres.

This Alberta survey estimated that there are 2,500,000 acres of black transition (good arable) land in the 9,000,000 acres surveyed and 1,000,000 of first grade wooded soil which, in general, is fairly good arable land. It must be assumed that part of this estimated arable acreage is waste land, but it indicates that there still is uncultivated arable land within reasonable distance of transportation facilities in the Peace River area.

As stated earlier in this paper, the large wooded soil zone lying north and west of Edmonton has up to the present relatively little cultivated land. Within its boundaries lie patches of good arable land. The major portion of the area is strongly degraded, heavily timbered land—land that will cost considerable to bring into production. It is, however, a vast potential source of farm land, if and when the demand for agricultural products warrants its development.

In conclusion, from the figures given in this paper it appears reasonable to state that, in the brown and dark brown soil zones of Alberta there is, under present farm practices and prices, all available arable land under dry land cultivation. There does appear, however, to be some unbroken arable land in the black and transition soil zones. The four areas described,

which make up the older settled portion of the province, are at present fairly well supplied with roads, railways, schools and other social services, and one of the questions that arise is this: If this land is farmed to get maximum production without causing soil deterioration, how near will it come to meeting our normal agricultural requirements? The answer to this question influences the rapidity with which new soil areas, areas to which social services would have to be supplied, should be opened for settlement.

In the present settled portion of the province, particularly in the shallow black, black and transition soils, there are many farmers who have now reached, some exceeded, the retiring age, and their farms are a potential source of available land for future settlement.

AN ECONOMIC PIONEER LAND SETTLEMENT POLICY[1]

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SUMMARY[3]

Under a laissez-faire policy of homesteading, the pioneer fringe has been a load on the State, wasting material and human resources, dragging out the pioneer stage and throwing the odds to a peasant type of settler rather than to the intelligent business-like type which stipulates decent social conditions and a reasonable standard of living.

The land-seeker pays in privation and hardship for the privilege of virgin opportunity.

Scattered, irregular entry and the throwing open of poor and ill-situated lands have been three main contributing causes, being especially disadvantageous in the bush.

These evils could be controlled by gently restraining the pioneer instinct, without destroying it.

The Crown lands should first be classified with a view to development along broad lines of conservation policy.

Bushlands should be partially cleared by wholesale spring firing before settlers are allowed to go upon them. Incidentally such controlled firing would be a protection to adjacent commercial timber.

Prisoners, unemployed and perhaps war internees might be used to chop the fire lanes necessary to lead spring fires through the green bush. Bulldozers might be employed.

Settlement should be co-ordinated with steel extension.

Homesteading should be abolished, squatting forbidden, and settlement strictly confined to reasonably clear lands reasonably close to present or immediately prospective transportation routes.

The quarter sections should be auctioned in blocks with due stipulations to prevent speculation, with a substantial down payment and with the remainder of the price amortized. Prompt residence and steady improvement should be demanded.

Shoestring pioneering should be discouraged.

Power breaking of a proportion of the cleared bushland in advance of settlement is worth considering.

Group settlement by race or religion, while holding certain advantages, is debatable for national reasons, but rearrangement to bring neighbours close together is worth considering.

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[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting, Olds, Alberta, June 18-19, 1942.

[2] Superintendent.

[3] Summary of an article printed in full in the *C.S.T.A. Review* No. 35, December, 1942, published by the Canadian Society of Technical Agriculturists, Ottawa, Ont.

AN APPROACH TO LAND SETTLEMENT PROBLEMS IN NORTHERN ONTARIO[1]

G. A. Hills[2]

The Great Clay Belt of Northern Ontario has been regarded for many years as a vast area of potential agricultural land (1). Definite knowledge as to the nature and extent of these potentialities has not been forthcoming, and in the past it has been deemed sufficient to assume that the region corresponded to that covered by Coleman's Lake Objibway (2) and estimated at approximately sixteen to twenty million acres of spruce-covered lands. It being further assumed that these lands were of approximately equal value, it would seem that there was ample land to care for the most optimistic army of settlers. But the failures experienced by war veterans under the Soldier Settlement Scheme following the last war and more recently by the Back-to-the-Land Movement have shown that more knowledge is necessary. Now, in view of the requirements of post-war rehabilitation and settlement planning, the need for an adequate inventory of the soil resources has become increasingly apparent. Accordingly in 1941 officials of the Dominion and Provincial Departments of Agriculture decided to project the Ontario Soil Survey into the north in order to delineate broadly and describe the soils upon which agricultural settlement might be developed.

During the first season, the area surveyed included those portions of the Great Clay Belt located in the District of Cochrane and served by roads and trails. The density of the vegetative cover over much of the area, the lack of a uniform road system, and the exploratory nature of the survey itself, made necessary the use of a mapping unit more inclusive and less precise than the soil type, and therefore based upon the criteria of landform and natural vegetation rather than upon soil profile development. Such a unit may be called a land type and, although it makes use of related natural qualities of the land, it is no less a natural landscape unit than those dependent on the soil characteristics alone. A further grouping of several related land types may be called a land class. For the sake of brevity, the latter, more generalized unit will be used in the following discussion.

Nine major land classes have been established, six of which are located on the deeper soil deposits associated with the former Glacial Lake Objibway and which constitute the Clay Belt proper. The Objibway Plain consists of gently undulating clay and silt deposits broken at frequent intervals by roughly parallel ridges of lighter fluvio-glacial materials. A diagrammatic cross-section of this eskerized plain is shown in Figure 1. Drainage, edaphic and climatic factors have combined to produce a surface layer of peat ranging from a few inches to 6 or more feet over most of the clay belt. This clay-peat complex was divided and placed into four land classes on the basis of topography, drainage, depth of peat and associated vegetation characteristics. Land class No. 1 occurs on the better drained areas dissected by stream courses or on comparatively low ridges where heavier

[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Convention, Olds, Alberta, June 18-19, 1942.

[2] Soil Surveyor, Experimental Farms Service, c/o Ontario Agricultural College, Guelph.

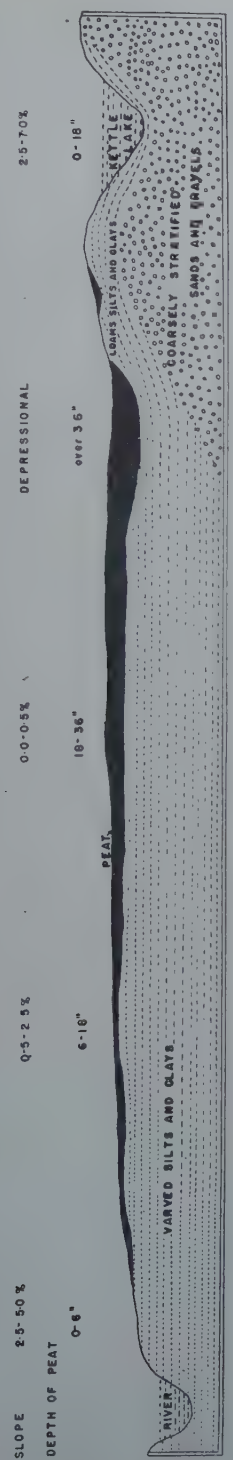

FIGURE 1. A DIAGRAMMATIC CROSS-SECTION OF THE SOIL MATERIALS OF THE GREAT CLAY BELT

materials cover a "core" of rock-knob or glacial debris. In this class are found soil profiles exhibiting a considerable degree of podsolic leaching. Land classes II and III are half-bog soils with a maximum peaty layer of approximately 18 to 36 inches, respectively. Land class IV includes the deep peat or muskeg. Land class V is a complex condition in which variable depths of intermediate and heavy textured materials overlie the fluvio-glacial sands and gravels. Under average conditions, the heavier surface layers supply fertility, and the lower open layers provide good drainage with the result that the most productive soils are found in local areas within this type. Outwash materials of intermediate texture are included in Land class VI. Ridges of coarse sandy and gravelly materials constitute Land class VII. Although these deposits are similar to the underlying materials of Land class V, the soils are droughty and low in fertility because of the absence of the heavier surface layer. Fairly compact, loamy, till soils constitute Land class VIII while the outcrops of the Precambrian rocks, with their shallow mantle of light soil are mapped as No. X.

The land Classes thus established are proving to be a useful basis for studying past and present land use. Since the building of the Canadian National Railway in 1912-13, settlers have been located over a tract of land whose frontiers extend some 300 linear miles and whose area approximates 1,000,000 acres. Many of these lands have been abandoned by the settler who is no longer interested in the land once the pulpwood has been removed. It is estimated that there are now approximately 2,000 farmer-settlers, but the number of these who actually make a living from the land is extremely small. It seems worthy of note that those who have "survived" under an economy of primary agriculture have done so only on the land

FIGURE 2

FIGURE 3

FIGURE 2. A common scene on Land class III. Typical of large areas of poorly drained peat-clay lands (Land class III), possessing fair potentialities and once covered with a good stand of spruce, they are now neither agricultural nor forestal. To develop the agricultural potentialities requires drainage, removal of most of the interbedded peat and tree stumps, and a number of years of good farm practices to build up a well-aerated soil with sufficient chemical and biological activity to ensure the aerobic decomposition of the resistant peat and the release of plant nutrients tied up in the intractable clay. It is apparent that, under the prevailing climatic and economic conditions, the returns from agricultural production are not sufficient to induce the individual to undertake the task unaided. Note the water in the ditch, the effects of moisture on the side of the house, and the black alder scrub in the immediate background.

FIGURE 3. A farm scene on Land class No. 1. Representative of the better, but extremely localized, areas of agricultural development in the Great Clay Belt, this dairy farm on Land class I is located within a few miles of the land shown in Figure 2 and has developed under the same transportation and marketing facilities. The difference lies mainly in the more undulating topography and associated characteristics. Although more easily drained and burnt-off, this type has not attracted the settler for several reasons. Because of the better facilities for logging and fire operations, the good stand of virgin forest has been removed, leaving the settler practically nothing as an immediate source of revenue. The tap roots of the deciduous trees make clearing a difficult task unless time is allowed for the stumps to decay. The podsolized surface soil is low in organic matter and plant nutrients and to bring it into full production requires a well-managed farm economy including live stock and crop rotation programs which a settler without funds finds difficult, if not impossible, to establish.

classes having a relatively high agricultural potential (Nos. I, II and V). Unfortunately, however, these "survivors" are scattered over a broad area, thereby losing much of their effectiveness. This leaves almost a million acres whose present use cannot be described as either agricultural or forestal, and which, while they cannot be rated as non-agricultural, have not responded to the present type of development. The disposition of these and similar lands present the most difficult problem now existing in Northern Ontario. For the remainder of the area still in forest this classification, or some modification of it to indicate age and condition of stand, could form a rational basis of classification of these areas.

The capabilities of these lands for agricultural or other use must then be determined on the basis of physical data, of present land use, and of the experience of settlers and experimentalists. The rating of each characteristic of the natural environment for each specific land use is desirable. Ultimately, however, there must be an evaluation of the natural charac-

FIGURE 4

FIGURE 5

FIGURE 4. An area of Land class V. The level to undulating clay and silt deposits of the Clay Belt are broken at frequent intervals by chains of kettle lakes similar to the one shown. Associated with them are long trains of coarse gravelly and sandy materials which frequently form associated ridges and in almost every case afford good internal drainage for the heavier clay and loam materials which are found at the surface. Selected portions of this land class form the best agricultural land of the district, some areas being exceptionally well-suited to the production of potatoes.

FIGURE 5. Erosion on Land class I. This photograph of an area of Land class I illustrates the erodibility of the clay and silt materials of the Clay Belt soils where the base water-level has been sufficiently lowered. Fortunately the common practice of leaving the fields in hay or pasture for long periods has assisted materially in erosion control. However, the problem will become acute once the protective covering is removed by a change in cropping practices, by a degradation of the soil and plant cover, or by fires in virgin areas. Extensive destruction by erosion after fire has been noted in similar areas not under agricultural development. Note the outcrop of Precambrian rocks in the background.

teristics which combine to form a particular landscape unit. Thus the land class forms a rational physical basis for the land capability ratings. For example Land classes I, II and portions of V have the highest agricultural potentials. Local conditions of soil drainage and climate in No. V are most favourable for the production of potatoes. Classes III and VI have only fair agricultural potentials. Few soils similar to those in Land class VII are used extensively for agricultural production in America at the present time. Land classes IV and X have practically no agricultural value. For forestal purposes areas of Classes I and V indicate the best saw-timber sites. In the mature stands of black spruce on Land class II, 2-log trees (which make 32 feet of pulpwood) are dominant while 1-log trees are common on Land class III. Portions of Land class VII are good pine lands.

The extent to which economic, political and cultural controls modify or define the development of these potentialities depends frequently on the nature of the inherent characteristics. For instance, in comparing the cost of developing Land classes I and II, the varying conditions of drainage, depth of peat, rooting habits of the forest cover, etc., must be considered since these determine the extent to which fire and other methods can be used economically. Furthermore, the relative cost, rate and manner of development of the various land classes will depend on the policy of the governing body, whether it leaves all to individual effort or lays plans for assisted concerted action.

While it is too early in the study to make recommendations it is evident that the land classes, with related data, possess definite possibilities of usefulness in this respect. The following is a suggested order for the agricultural development of the land classes on the basis of inherent characteristics only: V (sections only); I; II; VIII; VI; III; VII; IV; X. It is doubtful if large areas of No. III should be developed for many years to come and certainly not those in the lower categories. The above order of development, particularly with reference to the first six land classes, would vary according to the following factors,—

(1) Cost of development.
(2) Proximity to economical and social services.
(3) Plan of development.
(4) Pressure of population.
(5) Markets.

Finally, a plan of settlement can be more clearly outlined by the use of a series of maps showing how and when each area should be developed. In the clay belt it would appear that, for a time, at least, primary agriculture may not be the most practical economy on all lands potentially suited for agriculture. It is suggested that two distinct spheres be planned, one basically agricultural and the other basically forestal. In the planned development of agriculture, the potential areas should be large enough to permit the development of a centre which would provide adequate marketing, distributing, and social facilities. The effectiveness of such a program depends not only on the detail and accuracy of the basic physical and economic surveys but also on the efficiency of the co-ordination of all the factors.

SUMMARY

In the past, agricultural development in the Great Clay Belt of Northern Ontario has been slow in comparison with the progress in the transportation, mining, and deforestation frontiers. Future settlement in the area, however, appears inevitable and should proceed under careful supervision and planned assistance. During the 1941 survey nine major land classes were established. These are natural landscape units representing an integration of the physical elements of land-formation, geologic materials, drainage, and soils, together with the natural vegetation related to these conditions. It is suggested that such a classification could form the basis for settlement under the economy best suited to the potentialities of the land. In areas segregated for the practice of efficient farming, the proposed studies of the land classes can assist in their development, whether it be in the initial reclamation of virgin lands, in the rehabilitation of man-handled lands, or in the conservation of farm, forest, and recreational lands.

REFERENCES

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LAND SETTLEMENT IN NEW BRUNSWICK[1]

E. M. TAYLOR[2]

Land settlement in New Brunswick is continuous and has been continuous since the first settlement of the country. From Confederation until October 31, 1940, 14,562 grants totalling 3,014,686 acres have been issued by the Department of Lands and Mines. For the year ending October 31, 1940, 137 lots totalling 11,945 acres were granted. At October 31, 1940, 3,177 settlers totalling 10,766 persons were in process of earning grants on approximately 317,700 acres. During the past ten years settlement lots have been approved at an average of around 400 per year.

The acreage of land in New Brunswick held by the Crown at present is estimated at 7,500,000 acres largely forest land. This is a sizeable block of land but it is not inexhaustible. While no detailed survey has been made it is safe to estimate that a large portion of it is better adapted to forest production than agriculture and therefore should be considered as related to our lumber industry and should be given a second consideration from the standpoint of a moisture regulator affecting flood conditions in spring and stream levels and seepage during the summer for agricultural utilization. The above areas contain some sizeable blocks of land suitable for agricultural purposes. The colonization of such land might be given consideration when it is required for settlement purposes. It is recommended when such occasion arises consideration be given only to land adapted to agriculture and that forests be conserved to the utmost on land undesirable for agricultural purposes. It is also suggested that colonization of such land be on a settlement or community basis and not intermittent or on a here-and-there basis.

Land settlement or colonization in New Brunswick has been followed to some extent by land abandonment. In some instances small settlements have been largely abandoned, and in other cases it has been intermittent. There are various reasons for this including:

(a) In some cases the settlement followed good lumber chances, and depletion of the lumber and revenue from lumber where the land was not good agricultural land or the people not farmers at heart prompted abandonment.

(b) Free land in Western Canada.

(c) Migration to industrial areas in Canada and the United States.

(d) Last but not least, depression in agricultural revenue.

In an effort to maintain the agricultural settlement of the Province an act was passed by the Provincial Legislature in 1912 known as the Farm Settlement Board Act, the objective being the encouragement of our own young people to settle on the land, the repatriation of those who had left farms and wished to return to the land, the establishment of desirable immigrants, making use of land which had been developed for agricultural purposes and was in the process of being abandoned but at the same time utilizing only those lands which were useful for agricultural purposes.

[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Convention, Olds, Alberta, June 18-19, 1942.

[2] Secretary, New Brunswick Farm Settlement Board.

The regulations governing this act have been modified slightly from time to time but in the main they call for:

(a) Careful selection of settlers by an independent Board.

(b) An initial payment of from 20% to 25% of the cost of the farm, the balance to be paid with interest in equal annual instalments over a period not exceeding 30 years but in the main governed by the amount of principal outstanding.

(c) Settler must be able to finance or supply stock and equipment sufficient to start his enterprise.

The fundamentals for the successful operation of such a policy are:

(1) Careful selection of settlers.

(2) Selection of desirable farm land.

(3) Low initial cost.

(4) Adequate price for agricultural products in relation to what the farmer has to buy.

(5) Moderate payment plan.

(6) Investment on the part of the settler.

(7) A right attitude by the settler in regard to his financial obligation.

SUMMARY OF EXPERIENCE

Since the establishment of the Farm Settlement Board in 1912 a little over $1,350,000 has been invested in farm settlement for 1,069 persons; 489 accounts have been paid up; 536 active contracts are in effect; 50 farms are held vacant.

The original cost of the 536 occupied farms was $649,711.91. There is principal, interest and insurance owing on these farms totalling $467,170.36.

Book cost of the 50 vacant farms is $58,206.81 and the resale of these will entail a considerable loss. Interest loss on these has been written off.

The money borrowed to finance this investment cost 4% and 4½%. When the settler was charged 5% there was some spread for loss and administration. Since the settler is now charged 3% there is a recognized loss on interest alone.

The selection of settlers is not an easy proposition. In spite of the best consideration, the Board carries from 8% to 10% of the properties to which it holds title, vacant either by abandonment or repossession. Approximately 25% of the accounts might be referred to as not being in good condition.

Every failure means a loss, in fact two losses, a loss in the resale value of the property and a loss in carrying charges including interest.

The selection of farms is also a problem. In the early operation of the Board desirable vacant properties were bought with a view to their early settlement and the maintenance of community life. This policy was not found to be practical in operation. Prospective settlers have definite ideas as to where they wish to locate and will not readily change their minds. Many would-be farmers have an exaggerated opinion of land values and they make land purchase difficult at a right price.

During the years 1930 to 1940 farming was not a profitable enterprise. Even well established farmers got into financial difficulties during those years. As a measure of relief to settlers the interest rate was cut at May 1, 1939 from 5% to 3%. Since that time outstanding interest has been gradually reduced. The lower rate of interest prompted a better effort to meet interest charges. Improved farm prices were also an associated factor.

In the experience of the Board an investment on the part of the settler is desirable. An available down payment is a practical recommendation, and a personal investment is evidence of good faith.

Soldier Settlement Board

This Board was established following the last war for the re-establishment of soldiers in civil life. On March 31, 1941 the annual report of soldier settlement showed in New Brunswick 1,199 current-loans; 74 farms on hand; or a total of 1,273. Of the 1,199 current loans 473 were soldier settlers, 466 civilian settlers, and 266 British family settlers. Total investment in active loans and security on hand at book debt was stated at $1,275,129.03 as at the above date.

Farm Loans as Administered by Canadian Farm Loan Board

The Canadian Farm Loan Act was passed in 1927 and organization was proceeded with in 1929. The report of this Board at March 31, 1941 indicated that this Board had dispersed in New Brunswick 812 loans totalling $1,141,659.74; 761 loans were outstanding totalling $754,156.10.

SUMMARY

Four agencies operate in New Brunswick with a view to land settlement or the maintenance of settlers on the land. These four agencies have invested over $3,500,000 in the establishment of 5,797 homesteads. Approximately 700,000 acres is involved valued at $5,000,000. If we assume that the established farms, and farms in process of establishment in the Province total 40,000, one-seventh of these are publicly financed.

The conclusion of the war will necessitate consideration of the re-establishment of those engaged in war industry and active war services. The problem may or may not be as great as the magnitude of war operations would indicate. The restrictions in civil or peace time industry will result in a shortage of a great many lines of consumer goods. Industrialization in Canada is proceeding at a very rapid rate and at the end of the war this will be transferred to a peace time service. This transposition will require a good deal of labour and to restore the peace time requirements of consumer goods should require a generous amount of labour for a considerable time. Delayed public works will also be a factor.

The repatriation of those on active service is a different problem. Many of these will want to settle on land and the services and desires of those qualified should be respected. The Soldier Settlement Board is still in existence. This Board has had over twenty years of experience in land settlement and has developed or should have developed a sound sense of values and knowledge of human nature. If expediency will permit them to make this experience effective, a conservative policy of land settlement should be possible at the close of this war.

SOME ASPECTS OF SOIL EROSION IN EASTERN CANADA

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While no comprehensive study has been made as yet of the problem of soil erosion in Eastern Canada, it is possible, by assembling certain available data, to make at least a preliminary estimate of the magnitude of this problem.

At the outset it may be well to observe that, with the exception of one township near Toronto, no part of Eastern Canada has been covered by an erosion survey. The following comments are based on hearsay, personal observation, the results of one experiment at Ottawa, and data secured in erosion surveys conducted near the Canadian boundary by the Soil Conservation Service of the United States Department of Agriculture.

THE ADVERSE EFFECTS OF SOIL EROSION IN EASTERN CANADA

The adverse effect of gullying erosion is plainly evident. Sheet erosion, however, is more insidious in its action, and may escape detection for a considerable number of years. Nevertheless, sheet erosion may result in very great damage to extensive areas. The adverse effects of sheet erosion may be illustrated by the results of an erosion experiment which has been in progress on the Central Experimental Farm at Ottawa since 1935.

In this experiment the effect of varying degrees of sheet erosion on crop yields has been determined by growing barley on plots from which varying depths of the "A" horizon was removed. Mensury barley was grown each year for the six years with and without fertilizer, the fertilizer being drilled in with the seed at the rate of 200 pounds per acre of a 4-11-5 mixture. The surface layer or "A" horizon of the soil in this experiment was approximately 7 inches deep. The depth of soil removed and the average yield of barley secured on each treatment in this experiment is shown in Table 1.

[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Convention, Olds, Alberta, June 18–19, 1942.
[2] Soil Specialist, Field Husbandry Division.

Table 1.—Effect of sheet erosion on the yield of barley, Central Experimental Farm, Ottawa*

Soil treatment	Average yield of barley per acre (1935–1940 incl.)		Increase due to fertilizer,
	Fertilized	Not fertilized	
	bu.	bu.	bu.
Normal soil not eroded	48.7	35.9	12.8
3 inches of surface soil removed	39.6	28.8	10.8
6 inches of surface soil removed	25.1	16.1	9.0
All surface soil removed	12.2	4.4	7.8

*Soil: Grenville Loam—brown loam over yellow loam over calcareous grey till—slightly acid to alkaline; effervesces at about 20 inches; morainic; drainage good to imperfect. A typical soil of the grey brown podsolic zone. Maples, elms, birches and beech.

From the data presented in Table 1 the following conclusion may be drawn:

1. Most of the available plant nutrients are found in the "A" horizon. The sub-surface soil or "B" horizon is practically useless for barley production.

2. The productivity of the soil decreases rapidly in proportion as the thickness of the "A" horizon is decreased.

3. The efficiency of commercial fertilizer declines as the thickness of the "A" horizon is reduced.

The reduction in the average yield of barley which resulted from the removal of 3 inches of surface soil, amounting to 7 bushels per acre, would indicate the insidious nature of sheet erosion. Such a degree of erosion might well escape detection, particularly where deep plowing would mask the visible effect of erosion by mixing surface and sub-surface soil.

Under the conditions of the Ottawa experiment, therefore, the effect of sheet erosion is to reduce, markedly, the productivity of the soil, and to increase the difficulty of restoring fertility.

That the results secured in the Ottawa experiment are representative of a general condition is supported by an impressive array of data collected in the United States. It is not possible in a brief study to present these data, but one example may prove convincing. Table 2 illustrates the effect of sheet erosion in South Carolina. This land received applications of 400 pounds of a 4-10-4 mixture per acre per year.

TABLE 2.—COMPARATIVE PRODUCTIVITY OF TOP-SOIL, SUBSOIL AND SUBSTRATUM MATERIAL, SPARTANBURG, S.C. 1936–39 INCL.

Degree of erosion	Yield of seed cotton per acre Average—4 years.
	lb.
Surface soil (A horizon)	939
Subsoil (B horizon)	304
Substratum (C horizon)	81

THE EXTENT OF SOIL EROSION IN EASTERN CANADA

While no extensive soil erosion surveys have been made in Eastern Canada, it is possible to project some United States data into Canadian conditions. Two areas covered by erosion surveys by the United States Soil Conservation Service are located close to the border of Eastern Canada, one in northern Vermont near and comparable to the Appalachian region of Quebec, and one in the Presqu'Ile area of Maine, near and comparable to the potato growing area of New Brunswick.

The erosion survey in Vermont covered a block of some 90,869 acres of rolling to hilly land, of which 25% was in farmland and pasture, and the remainder was woodland covering hilly slopes. The results of this survey showed that more than 99% of the farmland in the surveyed area showed signs of water erosion, and 52% had lost from one-quarter to

three-quarters of the original surface soil. In view of the results secured in the erosion experiment at Ottawa, it might be safe to assume that the productive capacity of more than half of this farmland had been reduced by the equivalent of from 5 to 10 bushels of barley per acre. By reason of similarity in topography, soils and type of agriculture, the results of the Vermont soil erosion survey may be applied to much of the Appalachian region of Quebec.

In the Presqu'Ile area of Maine, the erosion survey, covering some 30,000 acres, showed that, on 6% of the total area, over 75% of top soil had been washed away, on 61%, from 25% to 75% of the top soil was gone; and on 11% of the area, slight erosion (25%) had occurred. The remainder of the area, mainly wooded, showed no evidence of erosion. If the results of the Ottawa erosion experiment can be applied to this region, it is safe to assume that on two-thirds of the area the yielding capacity of the soil has been appreciably reduced. It is also safe to assume that similar conditions obtain in the potato growing area of New Brunswick.

The foregoing remarks apply to land having a somewhat rugged topography. Much of the agricultural land in Eastern Canada is relatively level, and shows little evidence of severe erosion. Nevertheless, if we assume that the topography of only one-third of the agricultural land is sufficiently rough to promote erosion, and that two-thirds of this land in turn has lost from 25% to 75% of its original top soil, it would seem that on the average the productivity of two-ninths of the agricultural land has been reduced through erosion.

PRINCE EDWARD ISLAND SOILS AND CONTROL METHODS FOR SOIL EROSION[1]

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The soils of Prince Edward Island were formed from the sandstone, shale and limestone rocks of the Triassic Age which cover almost the whole area of the Province, and from the sandstone, shale, and limestone rocks of the Upper Carboniferous Age, which outcrop along the west shore from Nail Pond to West Cape, Prince County, at Governor's Island, and at Gallas Point in Hillsborough Bay, Queens County.

These rocks, during the Glacial period, were striated or grooved as the glaciers moved across the Island carrying with them the softer deposits of sandstone and shales, leaving ridges of the harder beds of sandstone, and forming, for the most part, gently undulating hills with broad valleys. The rounded ridges rarely exceeded 400 ft. in height. The glacial striation indicates ice movement in two definite directions, viz., N.E. and S.W. and N.W. and S.E., which corresponds to striation in other parts of Eastern North America.

The glaciers having denuded the Island of soil previously formed, brought later drift deposits and reclothed the naked valleys and ridges with fragments of the Upper Carboniferous and Triassic sandstones, shales and limestone rocks, boulder-clay, etc. The geologists tell us that the Island was submerged at that time and that after the glaciers, there came a period, Post-pliocene, when the surface was ground by icebergs, which were largely responsible for the occurrence of boulder-clay and sandstone fragments that make up a large part of the subsoils of the Province.

In many parts of the Island there are beds of stratified sand and gravel with occasional boulders resting on the boulder-clay. These beds indicate the action of the sea. The gravel and pebbles are all water-worn and are largely fragments of granite, quartzite, etc. They evidently had been transported considerable distances. There is evidence also that some of the stones and pebbles that are on the shore east of St. Peters, are of Laurentian origin and probably came from Labrador. The many travelling boulders that have been deposited all over the lower areas of Prince County were derived from the Metamorphic regions of Nova Scotia and New Brunswick while the Island was still under water. When Prince Edward Island was gradually emerging from the waters, further stratified sands and gravels were formed. Many of these occur near the top of the higher hills.

The primeval forest as recorded by Jacques Cartier, consisted of coniferous trees, including pines, cedars and yews (probably hemlock, spruce, and fir) and deciduous trees; willows and many others not known to Cartier.

Pine rampikes and stumps two and three feet in diameter, remain to this day and indicate that the surface soil was retained and augmented by a forest cover for centuries. The early settlers observed that the soil

[1] Presented to The Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting, Olds, Alberta, June 18-19, 1942.
[2] Superintendent.

from which deciduous trees had been cleared was more fertile than that where conifers grew. The Province was evidently heavily forested for centuries and the open spaces were grassed over or covered by peat bogs.

The first cultivation of Prince Edward Island soils was that carried on by the Indians of the Micmac tribe, a branch of the Algonquin race, one of the "six nations." Jacques Cartier on his first visit to the Island on June 30, 1534, thus describes the North Shore: "All the said land is low and flat, of the fairest that may possibly be seen, and full of beautiful trees and meadows. We, with our boats, went on shore in many places, and, among others, entered a goodly river but very shallow."

From North Cape, Cartier followed the west shore to West Point. On July 1st, 1534, he wrote: "We went that day on shore in four places, to see the trees which were marvellously beautiful and sweet smelling. The grounds where no trees are, are very fair and all full of peas, white and red gooseberries, strawberries, blackberries, and wild wheat like rye, which seemed to have been sown there and cultivated. This land is of the best climate that can possibly be, and very hot."

A few French settlements were founded on the Island in 1720. Near Port La Joie one "farming community gave little or no attention to other employments." The crops were abundant, amounting in 1730 to two thousand bushels of grain. Thomas Pichon, on a voyage to the Island in 1752, describes the soil about Charlottetown: "The soil is light, somewhat sandy and suitable for cultivation."

Sir J. W. Dawson, in his report of the Geological Structure and Mineral Resources of Prince Edward Island, published in 1871, describes the soils as follows: "The great wealth of Prince Edward Island consists in its fertile soil, and the preservation of this in a productive state is an *object of imperative importance.* The ordinary soil of the Island is a bright red loam, passing into a stiff clay on the one hand, and a sandy loam on the other. Naturally it contains all the mineral requisites for cultivated crops, while its abounding in peroxide of iron enables it rapidly to digest organic manures and also to retain well their ammoniacal products."

Dr. Frank T. Shutt, Dominion Chemist, in his Bulletin No. 100, "The Soils of Prince Edward Island, Their Nature and Composition," published in 1928, states: "In respect to texture, colour and physical characters generally, the soils of this series are very similar; they are soils for the most part which have been derived from the soft red sandstones and other representatives of the Triassic formation. According to accepted classifications, practically all these soils would be classed as 'sandy or fine sandy loams' only two or three contain sufficient silt or clay to class them as loams."

From these references, it seems evident that considerable erosion had occurred between 1871 and 1928. The soils analyzed by Dr. Shutt had in most cases been cultivated for 100 years or more. With the loss of the clay and silt particles, their general classification had changed from "bright red loam" to "sandy or fine sandy loams."

The gradual loss of clay and silt is shown by the deep deposits of mud in the rivers and bays of the Province. When piers were sunk to carry the Hillsborough Bridge at Charlottetown, the workmen had to go down

through 90 feet of mud to get a solid foundation. More recent losses are shown by the silting up of many of the millponds and the courses of streams throughout the Province.

The actual amount of soil that has been removed from any given area is difficult to determine. In 1910, a survey of an area at the Charlottetown Experimental Station was made for drainage purposes. This same area was surveyed again in 1939 in connection with the laying out of a Soil Erosion Experiment. On checking back from the bench marks, the loss from areas with 10% slope was about 6 inches, while on the lower areas, a gain of 4 inches of soil was recorded.

The early settlers who came out with Lord Selkirk and others in 1803, introduced the Scottish seven-year rotation which had four years of hay or pasture. This rotation added much humus and there is no question that, with 60% of the cultivated land in sod, soil erosion was very greatly retarded.

Dr. James W. Robertson when he was Commissioner of Agriculture, in the Dominion, introduced co-operative dairying for the manufacture of cheese. Mixed farming, centered around the dairy industry, made rapid strides until there were 63 cheese factories in the province. Many of these secured additional equipment and manufactured butter in the winter.

While there was a tendency throughout the Island to shift from cheese to butter making, mixed farming continued as the general practice of the farmers. Fur farming and the growing of cash crops, including potatoes and table stock turnips, has introduced changes, and in some districts has shortened the farm rotations to four and even to three years' duration.

This shortening of the rotation and the use of large quantities of fertilizers in place of barnyard manure, has greatly increased soil erosion and the wastage of the most valuable constituents of the soil.

While it is true that nature is forever washing away and moving parts of that thin earth covering that we call soil she has also, through the centuries and ages, gradually built up over vast areas, a productive surface soil that has been responsible for the subsistence of the human race ever since it appeared on the earth. This mere shell of vital soil matter is indispensable to man. It is one of the five essential gifts of nature that nourishes plant life and supports all animal and human life, namely: soil, water, heat, air and sunlight.

Knowing something of the time and the millions of plants and minute forms of life that nature has used to build even one inch of top soil, why should we, by careless acts or unwise methods, waste in a generation or less, this storehouse of fertility on which human life depends?

One of the most wasteful farm practices that is common throughout every district of Prince Edward Island is that of making the rows of cultivated crops run directly up and down the slope of the fields. This method does not have anything to commend it. It is actually the hard way for man and beast and has caused an ever increasing amount of waste of the most valuable soil particles which contain most of the fertility in our soils, by helping the rains and melting snow to carry them away.

Dr. H. H. Bennett, Chief, Soil Conservation Service, Department of Agriculture, Washington, D.C., in a recent article, "Thirty Years of Vertical Farming," tells something of what has happened in the Aroostook potato district of Maine. He refers particularly to the 220,000 acres of ideal potato soil known as Caribou loam. Thirty years ago, he surveyed the area. The top soil was then mellow and dark in colour. Two years ago, after examining it again, he states: "I hadn't counted on any such prodigious change in the soil as I actually found—change caused by erosion." He states later in the article: "One thing that hadn't changed was the direction of the potato rows. Most of them, except on farms that had co-operated in the Soil Conservation Service demonstration project, still ran straight down the hill." He refers to a field that 32 years ago had a combined soil and subsoil depth of at least two feet: "In which the average depth of the subsoil—the original soil is all gone—is less than 12 inches today." . . . . "In other words, more than a foot of soil and subsoil, amounting to 32,000,000 lbs. per acre, had been unnecessarily wasted in this field."

After visting some of these fields in company with soil conservation agents of the United States Department of Agriculture, convincing evidence was seen to indicate that Prince Edward Island soils with rows down the slopes, are losing soil fertility more rapidly than has occurred in Maine. Maine soils have great quantities of small, hard stones and gravel that soon line the sides and bottom of rivulets and gullies as the soil washes away, producing a natural protection. Very few of our fields have any hard stones or gravel so that gullies cut deep and wide.

Serious damage and loss from water erosion occurs in Prince Edward Island during the autumn, winter and spring to unfrozen soil in the ploughed lands, and after hoed crops, even when the land is not ploughed. Wherever there is a slope, small streams and rivulets form during heavy rains or when the snow melts rapidly; these quickly form water courses and small gullies, which, if not checked, soon form deep gullies that have to be filled before the crops are planted again. The greatest loss, however, is not noticeable and consists of the fertility carried away in solution or in the small soil particles that make the water muddy. Some believe that much more fertility is lost in this way than is added by all the commercial fertilizer bought each year by our farmers. This represents many hundreds of thousands of dollars.

CONTROL OF WATER EROSION OF SOIL

A project on control of water erosion was begun at the Charlottetown Experimental Station in the spring of 1939. The site chosen comprised former Rotations B and D, on the westerly slope between the Station buildings and the Canadian National Railway, where the slope of the land averaged about 10-foot fall in one hundred, or a 10% slope. A spillway has been grassed over, and a low dyke on the west side was constructed to prevent the runoff and waste from injuring the adjacent cereal plots.

The project is in three sub-divisions or rotations:

Rotation 1 is a 4-year rotation: potatoes, barley, clover and timothy, which run in sections each 50 ft. wide by 360 ft. long, parallel to the contours. Each section is divided into three plots 120 feet long and treated as follows:

Plot 3—No manure.

Plot 2—Apply 10 tons manure in the autumn before ploughing the timothy sod for potatoes and supplement with fertilizer in the spring.

Plot 1—Same as 2 with the addition of a seeding of rye in the autumn on the timothy sod, after the potatoes are dug, to hold the soil in the autumn, winter and spring.

Rotation 2 has the same rotation as No. 1, and similar treatment, except that the strips run at right angles to the contours or down the slope, and rye is not used to hold the soil during the autumn, winter and spring.

These two rotations can also be compared with a similar rotation C on upland where there is less than a 3% slope. Rotation 3 is a 3-year rotation; potatoes, barley and clover with a grassed strip of 16 ft. between each section of the rotation. These strips and the rotation sections follow roughly the contours. Manure and fertilizer are used for the potato year in the rotation. The first test came with heavy thunder showers on July 13, 1939, when 0.64 inches of rain fell in 12 hours. The potatoes planted along the contours did not suffer but, where the drills ran down the slope sub-division 2—small gullies 6 inches wide and 2 inches deep were formed, and much soil was carried to the lower levels of the field.

In the spring of 1940, very little erosion had occurred on any of the areas seeded. There had been some loss of soil on the potato land on the steeper slopes of both rotations 1 and 3. The fall rye was distinctly helpful in preventing wash on the areas where it was sown. Records taken on May 3, 1940, on rotation 2, show that there were numerous gullies cut on the red fields 3 to 6 inches wide and 3 to 6 inches deep. These were smaller near the top of the field and increased in size as they reached the bottom of the slope. A great deal of sediment had been carried down and deposited on the spillway. On June 13, shortly after the potatoes were planted, a rainfall of 0.56 inches fell in 3 hours and caused considerable erosion on this area. Where the potato drills followed the contours, the water was held and soaked in without any damage.

August, 1940, had a rainfall of 1.78 inches, about half of the average for that month for 40 years. September had a rainfall of 8.05 or, much more than twice the average of that month for 40 years. These rains carried from 1 to 2 inches of soil out of every potato drill on rotation 2. In contrast to this, the potato drills along the contours on rotations 1 and 3 had the soil moved only a few inches and some of this was up the hill from the east side of the potato drills.

The value of making the potato drills along the contours instead of down the slope was clearly demonstrated, during the winter of 1940-41. The potato digging in the autumn of 1940 was followed by harrowing lengthwise of the drills on both areas to gather potato tops and tubers left at digging. In the late autumn and during early spring where the light marks

of the harrow ran down the slope, small channels and rivulets were formed by the run-off; where these joined, numerous small gullies 5 to 6 inches wide and 3 to 4 inches deep were cut in the lower slope of the field and 2 to 3 tons of soil were carried onto the grass spillway.

On the areas where the drills were along the contours no erosion occurred as the water was held between each small depression made by the teeth of the harrow. The other sections of rotations 1 and 3 showed numerous instances where the soil from the cultivated areas, if moved at all, was held in a short distance by the grassed areas.

The growing season of 1941 was unusually wet with just twice the average rainfall for the 4 months, May to August, and considerable erosion was recorded on the cultivated crops on rotation 2, though not as severe as that caused by the sudden storms of 1940 when the dry soil was loose from cultivation.

SUMMARY AND GENERAL RECOMMENDATIONS

Prince Edward Island soils, on account of their nature and formation, are very subject to water erosion. The steep hillsides of the province should remain in forest or be replanted to forest trees. Cleared areas that have over 15% of a slope should be sown to grass and only broken occasionally. All slopes, even those with plenty of humus and root fibres, are apt to wash and waste seriously when cultivated crops are grown in rows up and down the hills.

Contour or strip farming is recommended for all slopes that are over 5%. Wherever there is a heavy flow of water from melting snow or rain over cultivated land, spillways and water courses should be constructed. These should be graded slightly from the center both ways and grassed with hardy tenacious grasses. The growing of plants is Nature's way of holding soil fertility. Where necessary, terraces can be used to save valuable farm land. Much soil fertility will be saved by thus diverting and slowing up the flow of surface run-off.

Fall rye or winter wheat sown in September or early October is one of the best control measures against water erosion.

Single furrows carefully run across the slope to slow up the flow of surface water are beneficial. Stubble, trash, and brush can be used as obstructions to slow up the flow of water at points where small streams and gullies may occur, since the carrying capacity of water is greatly increased by the rate of flow.

All large soil conservation systems should be on a co-operative basis. In this way, experienced supervision is possible and suitable equipment can be secured to save our farms from erosion.

EFFECTS OF CULTIVATION AND CROPPING ON THE CHEMICAL COMPOSITION OF SOME WESTERN CANADA PRAIRIE SOILS[1]

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PART II

Soil deterioration has long been a problem in agriculture because in any system of permanent agriculture one of the first concerns should be the maintenance of soil fertility.

Farming practices have been very similar over wide areas of the Prairie Provinces, consisting largely of grain and fallow systems claimed by many to be wasteful of soil fertility. In this study an attempt has been made to determine by chemical analysis of some cropped and virgin soils what effects the present methods of farming have had on some total and available or easily soluble plant foods.

While obvious erosion, both by wind and water, plays a great part in soil depletion, it is outside the scope of this investigation. This particular project has been chiefly concerned with losses from cultivated soil because of decomposition of organic matter and removal of essential plant nutrients by crops. However, it is quite likely that erosion often plays a part in soil deterioration under cultivation even when the effects are not readily observable.

A paper on this work was presented at the Canadian Society of Technical Agriculturists' Convention in 1938, and was published later in *Scientific Agriculture* (1). However, further work has been carried on and, as a matter of fact, is still continuing. The earlier analytical work on the project was done by Dr. A. C. Caldwell. The following discussion gives only a summary of the investigation up to the present time. The data and details of this investigation will be published at a later date.

MATERIALS AND METHODS

While the technique has been similar to that used in the previously published work a brief outline of the procedure followed is perhaps in order at this time.

Samples were collected in the field to represent the virgin soil and the cultivated soil nearby. These were all composite samples for the first two depths and were taken in duplicate. Usually samples were taken as representative of a soil zone such as black soil, or gray wooded.

An attempt was made to sample cultivated and adjacent uncultivated soils that were uniform in texture and profile, and free from erosion or drifting. It is probably impossible to avoid erosion and drifting entirely and in this case it was a matter of personal judgment. Something of the

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[1] Presented to the Soils Group of the Canadian Society of Technical Agriculturists at the Annual Convention, Olds, Alberta, June 18-19, 1942. This investigation was made possible by a grant under the P.F.R.A. and conducted in co-operation with the Experimental Farms Service, Dominion Department of Agriculture.

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[3] Professor of Soils.

[4] Professor of Soils.

history of the field was always obtained, such as length of time cultivated, types of crops grown, rotations used, and fertilizers and manure applied, if any. Usually fertilized fields were avoided since this would complicate the particular problem.

Once the samples were obtained, they were taken to the laboratory where they were air-dried and pulverized before being analyzed. Up to the present over 1,000 samples (representing 51 locations) have been collected from various points in Alberta (including the Peace River area), Saskatchewan and Manitoba. Analyses have included total nitrogen, organic carbon, total phosphorus, easily soluble phosphorus, water-soluble phosphorus, some pH determinations and a few sulphur determinations. Nitrification studies and carbon dioxide evolution studies have been carried on with some of the surface samples. Carbon : nitrogen ratios have been calculated from percentage organic carbon and percent nitrogen.

RESULTS

Nitrogen

Losses of nitrogen per acre have varied from 96 pounds to over 7,000 pounds to the depth analyzed.

Average losses for the surface 6 inches in the cultivated brown, dark brown, black, black transition, gray transition and gray soils have amounted to 17%, 18%, 18%, 22%, 18% and 22%, respectively.

For the 6- to 12-inch depth the black and black transition cultivated fields have apparently lost on the average 688 pounds and 388 pounds of nitrogen respectively. The other zones showed much smaller losses for this layer, and gray transition cultivated soils contained on the average 180 pounds more than the uncultivated.

A statistical analysis of the nitrogen results shows that all soil zones have suffered significant losses of nitrogen caused by cultivation and cropping in the surface layer. In the second depth, however, only the losses in the black and black transition soils are significant.

The results indicate that the largest losses of nitrogen have occurred from soils originally high in nitrogen. The results reported also indicate that the rate of loss of nitrogen is more rapid for the first few years following the initial breaking of the sod.

Organic Matter

Organic matter losses have ranged from 1 ton to over 90 tons per acre to the depth analyzed.

The losses for the surface 6 inches of cultivated brown, dark brown, black, black transition, gray transition and gray soils have amounted to 24%, 22%, 21%, 27%, 25% and 29% of the original organic matter.

A statistical analysis of the data reveals significant losses of organic matter in all soil zones for the surface 6 inches and also significant losses in the 6- to 12-inch depth in all zones except the brown soils.

The results indicate, as in the case of nitrogen, that the greatest losses have occurred from soils originally high in organic matter, and also that the rate of loss is greatest in the first few years after the virgin sod is broken.

C : N Ratios

The majority (four-fifths) of the cultivated fields have shown a narrowing of the carbon : nitrogen ratio in the surface layer as a result of cultivation and cropping. About three-quarters of the fields have shown a similar narrowing in the subsurface layer (6 inches to 12 inches).

This substantiates the evidence that the organic carbon is depleted faster than is the nitrogen. It is interesting to note that the gray soils originally had by far the widest carbon : nitrogen ratios, and also that they show the greatest narrowing of the ratios in the cultivated soils.

Carbon Dioxide Evolution

Closely associated with the losses of organic matter are the CO_2 evolution studies. The amount of CO_2 given off from a 100-gram sample at optimum moisture was measured for a period of two weeks. The indications are that the virgin sod gives off more CO_2 than does the cultivated soil. However, in some cases this difference is very small, especially after two weeks incubation. Further work along this line is continuing.

Phosphorus

The average losses of phosphorus in the surface 6 inches of cultivated brown, dark brown, black and gray soils have amounted to 100 pounds, 163 pounds, 103 pounds, and 101 pounds respectively; (or 7%, 11%, 5%, and 7%). The statistical analysis of the data, however, shows significant losses only for the dark brown and gray wooded soils. The gray wooded soils have also shown significant losses of phosphorus in the 6- to 12-inch depth. The other soil zones do not reveal any significant decrease in this second layer.

The results for easily soluble phosphorus have not been very consistent. The cultivated black soils appear to contain less easily soluble phosphorus than the virgin soil, but in the dark brown and gray soils the reverse appears to be the case. The brown soils have not shown much difference between virgin and cultivated soils in regard to content of easily soluble phosphorus.

While the differences in water soluble phosphorus in cultivated and virgin surface soils have been quite small, nevertheless statistical analyses reveal significant losses of this phosphorus in the dark brown, brown and gray wooded soils.

Nitrification

Nitrification studies on some surface virgin and cultivated samples have shown that in 7 out of 10 cases the virgin soil has the greater nitrifying power or nitrate content after a period of three months incubation. However, the cultivated soil still was capable of producing fairly large amounts of nitrate nitrogen.

Leaching has been shown to reduce greatly the nitrifying power of both the virgin and cultivated soils, although in most cases the virgin soil still had a slightly greater recovery power.

Sulphur

Some workers have reported a decrease of sulphur in the soil as a result of cultivation and cropping. However, as yet, our results are inconclusive.

One or two locations have shown small decreases of sulphur, but several have shown no such decrease. The method of analysis still remains a problem, and much more work is required on this particular element.

Soil Reaction (pH)

Some workers have reported a lowering of the pH of soils after cultivation and cropping; others have found no change. Our work on pH seems to favour a slight increase in the pH or a more alkaline soil following cultivation and cropping. The results are not very consistent, however, and therefore more work will have to be done to establish the influence of cultivation and cropping on soil reaction.

CONCLUSION

Probably the most significant feature of this work has been the large losses of organic matter from our soils. Organic matter, besides serving as a source of plant food, also improves the physical condition of the soil. Organic matter greatly increases the water-holding capacity of the soil and fibrous organic matter is an important factor in controlling erosion by wind and water.

If, in 30 years, we have lost one-fifth to one-third of the organic matter from our soils, very soon we must start replacing or at least maintaining it, possibly by grass or legume rotation. By including such crops as grass or legumes in a rotation, the organic matter can be replaced to some extent and the physical condition of the soil can be improved.

Our information is not complete. Further work is required on pH, base exchange, CO_2 and nitrogen evolution, sulphur, potassium, calcium, and magnesium, to mention some of the future analyses that could be done.

REFERENCE

1. Caldwell, A. C., F. A. Wyatt, J. D. Newton. Effects of cultivation and cropping on the chemical composition of some Western Canada prairie soils. Sci. Agr. 19 : 258-270. 1939.

THE ACCUMULATION OF NITRATES IN OAT STRAW[1]

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The poisoning of livestock by the ingestion of oat hay or straw has been the subject of numerous investigations, but it is only during the past few years that the cause of the toxic effect has been definitely determined. Experiments conducted by Bradley, Eppson and Beath (3) have shown that the lethal action was due to the high concentration of potassium nitrate in the suspected feed. The nitrate is reduced to nitrite by bacterial action in the digestive tract of the animal and then enters the blood stream. The nitrite causes the formation of methemoglobin, which interferes with the transfer of oxygen from the lungs to the body tissue and may cause the death of the animal within a few hours.

One major loss of livestock in Saskatchewan has been definitely traced to the high content of nitrate in the oat straw being fed to the animals. Other losses have occurred where stock had access to high nitrate straw and it seems likely that many cases of unexplained losses may have been due to the same cause.

Bradley and his co-workers have tentatively set the lower toxic limit at 1.5% potassium nitrate which is equivalent to 0.2078% nitrogen as nitrate. This concentration is much higher than has generally been reported for cereal straw. Cook (4) has shown that nitrogenous fertilizers tend to increase the nitrate content of the expressed sap of the small grains. Strowd (7) found that nitrate accumulated in soy bean leaves proportionately to the concentration in the root medium. Work by Emmett (6) has shown that drought conditions increased the nitrate and potassium in the sap of the tomato plant.

The investigations reported in this paper were undertaken to determine if high concentrations of nitrate in oat straw were of frequent occurrence and some of the factors contributing to such accumulation.

EXPERIMENTAL WORK

Greenhouse experiments were conducted to determine the effect of soil type and nitrate fertilizer on the nitrate content of oat straw. Samples of straw were collected from fields covering a wide range of territory to determine the frequency of occurrence of high nitrate content.

Methods of Analysis

Total nitrogen to include nitrates: digest with sulphuric and salicylic acids. Official Methods of Analysis (1).

Nitrates. Leach straw with hot water and determine colorimetrically. Official Methods of Analysis (1).

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[1] Contribution from the Experimental Farms Service (P.F.R.A.), Dominion Department of Agriculture, Ottawa, Canada. Presented to The Soils Group of the Canadian Society of Technical Agriculturists at the Annual Meeting, Olds, Alberta, June 18-19, 1942.

[2] Senior Soil Specialist and Agricultural Assistant, respectively.

Preparation and Clarification of Extract (2)

Add 206 ml. of boiling water to 10 gm. of finely ground plant tissue, shake for 30 minutes and filter. To 10 ml. of the extract add 10 ml. of a solution containing: 100 ml. saturated Ag_2SO_4 and 6 gm. $CuSO_4.5H_2O$ per liter. Add 0.5 gm.$Ca(OH)_2$ and 1 gm. carbon black, mix and filter. This method gives a clear solution suitable for the colorimetric determination of nitrate.

Pot Culture Work

Seven soils typical of those in the surrounding districts were used for pot culture work in the greenhouse. Glazed gallon crocks were used for containers each holding 10 lb. of soil and supporting 3 plants. The field capacity of each soil was determined and the moisture content brought up to this value at each watering. The following treatments were set up in triplicate.

Check.
50 lb. N as KNO_3 per acre.
150 lb. N as KNO_3 per acre.
150 lb. N as KNO_3 + 100 lb. T.S.P. per acre.

The high rate of nitrogen application was used to determine if excess nitrate would accumulate in the plant. These rates are much higher than would be used in the field, but soil that has been summer-fallowed may contain from 50 to 75 p.p.m. of nitrogen as nitrate which is as high as the above rates.

One crock in each treatment was harvested at the time of heading and is listed as immature in Table 1. The third crock in each treatment was subjected to a partial drought after the plants had started to head. The data in Table 1 show that the application of KNO_3 caused a definite increase in the nitrate content of the straw. A further increase was obtained in practically every case by the application of triple super phos-

TABLE 1.—THE EFFECT OF KNO_3 AND PARTIAL DROUGHT ON THE CONCENTRATION OF NITRATE IN OAT STRAW

Treatment	Condition when cut	Cypress L.	Cypress C.L.	Haverhill L.L.	Weyburn L.	Cypress L.	Haverhill C.L.	Sceptre C.
		N as NO_3	N as NO_3	N as NO_3	N as NO_3	N as NO_3	N as NO_3	N as NO_3
		%	%	%	%	%	%	%
Check	Immature	0.002	0.006	0.008	0.002	0.007	0.072	0.007
Check	Ripe	0.010	0.007	0.006	0.014	0.025	0.011	0.022
Check + drought	Ripe	0.029	0.005	0.027	0.049	0.104	0.007	0.033
50 lb. N	Immature	0.035	0.023	0.130	0.036	0.031	0.006	0.033
50 lb. N	Ripe	0.032	0.136	0.104	0.077	0.102	0.043	0.160
50 lb. N + drought	Ripe	0.128	0.088	0.224	0.115	0.324	0.096	0.076
150 lb. N	Immature	0.400	0.330	0.540	0.390	0.480	0.415	0.340
150 lb. N	Ripe	0.533	0.880	0.776	0.560	0.700	0.426	0.440
150 lb. N + drought	Ripe	1.200	1.200	1.067	0.900	1.133	1.067	0.850
150 lb. N + 100 lb. T.S.P.	Immature	0.550	0.650	0.505	0.585	0.660	0.560	0.355
150 lb. N + 100 lb. T.S.R.	Ripe	0.946	0.960	0.850	0.720	1.000	0.620	0.552
150 lb. N. + 100 lb. T.S.P. + drought	Ripe	1.426	1.380	1.080	1.100	1.267	1.052	1.027

phate. Drought conditions during the heading and ripening period increased the nitrate content in all but 3 crocks, which is in keeping with Emmett's work (6). The type of soil had no apparent effect on nitrate accumulation in the crop.

While this experiment was of a preliminary nature it definitely indicated that appreciable quantities of nitrate in the soil would increase the nitrate content of the grain. Subsequent work has confirmed this. It would seem logical to assume that a soil in which nitrates formed rapidly would produce a crop having a higher nitrate content than one grown on soil in which nitrification was slow. Likewise a crop grown on summer-fallow land would likely be higher in nitrate than one grown on stubble land.

Data are presented in Table 2 showing the yield of grain and straw in grams per crock and the total nitrogen in the grain and straw for one of the soils. Similar results were obtained with the other series. The total nitrogen in the grain and straw follows the same trends as the nitrate nitrogen in the straw, increasing with increased application of nitrate and drought. Although the plants subjected to drought contained a higher percentage of total nitrogen, the actual amount of nitrogen absorbed from the soil was less than for the plants having adequate water.

TABLE 2.—THE EFFECT OF KNO_3 AND PARTIAL DROUGHT ON THE TOTAL NITROGEN IN OAT STRAW AND GRAIN

Treatment	Cypress Loam				Grain Total N
	Yield		Straw		
	Grain	Straw	N as NO_3	Total N	
	gm.	gm.	%	%	%
Check	3.8	5.3	0.010	0.37	1.97
Check + drought	2.4	5.1	0.029	0.56	2.36
50 lb. N	5.0	9.3	0.032	0.48	2.44
50 lb. N. + drought	3.4	7.3	0.128	0.92	2.41
150 lb. N	5.4	11.0	0.533	1.37	2.61
150 lb. N. + drought	3.4	3.7	1.200	2.07	2.92
150 lb. N + 100 lb. T.S.P.	6.5	11.9	0.946	1.38	2.80
N + T.S.P. + drought	3.6	6.5	1.426	2.17	3.33

Field Samples

Samples of crops were collected in the fall of 1941 from fields covering a wide range of territory in Saskatchewan and Alberta. Analysis of 65 samples of oat straw showed that 22 contained 0.2% or more of nitrogen as nitrate thus being potentially dangerous according to the tentative standard set by Bradley *et al.* (3). The percentage of nitrogen as nitrate varied from 0.003 to 0.556 with a mean of 0.165. Four of these samples were from cover crops cut when approximately 14 inches high, and they all contained over 0.32% of nitrate nitrogen.

The data in Table 3 show the total and nitrate nitrogen in the grain and straw from crops grown on fallow and stubble land. In several cases samples were secured from adjacent fallow and stubble crops where soil

TABLE 3.—THE TOTAL AND NITRATE NITROGEN IN FIELD SAMPLES OF OAT STRAW AND GRAIN

	Straw		Grain	
	N as NO_3	Total N	N as NO_3	Total N
	%	%	%	%
Fallow crop	0.257	1.45	0.012	2.84
Fallow crop	0.406	1.17	0.023	2.52
Fallow crop	0.556	1.13	0.013	2.41
Fallow crop	0.436	0.98	0.012	2.02
Stubble crop	0.026	0.84	0.004	2.18
Stubble crop	0.060	0.80	0.005	2.23
Stubble crop	0.005	0.51	0.002	1.81
Stubble crop	0.004	0.36	0.002	1.79

and climatic conditions were similar. The total and nitrate nitrogen was higher in the crops grown on the summer-fallow, a condition that has held for all samples examined where the previous treatment of the land was known. All the grain samples analysed have contained only small amounts of nitrate. In no case has a field sample of oat straw from a crop subject to drought throughout the season contained a high content of nitrate. As nitrification would be slow or absent under drought conditions, the plant would not have access to a large amount of nitrate.

Twenty samples of wheat straw have been analysed and in all cases the nitrate nitrogen has been below 0.07%. One of 7 samples of barley straw was above the lower toxic limit. This crop was grown on summer-fallow and was subject to drought during the later period of growth. The other samples were all low though in general higher than the wheat straws.

SUMMARY

The application of KNO_3 to soil in pot cultures increased the nitrate content of oat straw. Drought during the heading and ripening period also increased the nitrate content. High concentration of nitrate are of frequent occurrence in oat straw grown under field conditions. Crops grown on summer-fallow land contained more total and nitrate nitrogen than crops grown on stubble land. All wheat straws examined were relatively low in nitrate.

Analyses indicated that the nitrate in the straw was combined with potassium.

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CULTURAL STUDIES WITH BARLEY

IV. SUMMARY OF RESULTS FOR YIELD AND MALTING QUALITY[1]

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[Received for publication November 18, 1941]

With the increase in the past twenty years in the domestic production of malt, for internal and export trade, and some pre-war signs of an improving export market for Canadian barley, additional attention has been focussed on the production of high class malting barley. Various programs have been undertaken by the National Barley Committee, with the cooperation of many companies and institutions, looking to improvement in the quality of Canadian barley. It may be noted that although the primary object of most of the investigations was better malting quality, this must also involve an improvement in barley for feeding. The studies reported herein on the effects of cultural practices on yield and malting quality were undertaken as part of the general program of the National Barley Committee.

Investigations of the effects of various cultural practices on yield and quality were started in 1935 and carried through to 1939. The results covering the period 1937–1939 have been published in separate papers (1, 2, 3). The first dealt with the effects of date of seeding on yield, the second with the effects of rate of fertilizer and rate of seeding on yield and the third with the effect of date of seeding, rate of seeding and rate of fertilizer on malting quality. The reactions of three varieties, O.A.C. 21, Mensury Ottawa 60, and Gartons, to changes in the factors mentioned were studied in these investigations. It seems advisable at the present time to present a summary and comparison of the results published in the three previous papers in order that the information may be made available in convenient form for dissemination by agricultural leaders to those who wish to obtain information that would assist in the production of optimum yields of high quality barley. This assumes particular importance in Western Canada at this time when there is a demand for barley and wheat is being replaced in some districts by barley.

MATERIALS AND METHODS

The design of the experiments and the methods by which they were carried out were given in detail in Parts I and III (2, 1) but it seems advisable to note in this paper that three varieties were compared in field tests at four stations in 1937, 1938 and 1939 by means of a factorial experiment involving three levels each of date of seeding, rate of seeding and rate of fertilizer. That is, each variety was tested with each of the nine combinations of the three cultural factors at each station in each year. Malting

[1] Contribution from the Division of Plant Science, the University of Manitoba, with financial assistance from the National Research Council, the Dominion Department of Agriculture and grain handling organizations. Published as Paper No. 202 of the Associate Committee on Grain Research.

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tests were made on samples representing the 1937 and 1938 crops. For convenience, the individual factors are listed below.

Varieties: O.A.C. 21, Mensury Ottawa 60, Gartons.

Dates of seeding: 3 consecutive dates of seeding at about 14 day intervals, the first date being as close to May 1 as possible.

Rates of seeding: 1. 1 bushel per acre. *2.* $1\frac{3}{4}$ bushels per acre. *3.* $2\frac{1}{2}$ bushels per acre.

Rates of fertilizer: 1. No fertilizer. *2.* 96 lbs. per acre, 16–20–0. *3.* 40 lbs. per acre, 11–48–0.

RESULTS AND DISCUSSION

Before presenting the results of the investigations in the sections that follow it seems advisable to review briefly the criteria of malting quality. Malting quality is evaluated mainly by percentage heavy kernels and malt extract, which should be as high as possible, and by barley nitrogen content, in which high values are undesirable. In the discussion on the effects of cultural practices on malting quality these are determined by the effects on all properties, and usually the data for at least two of the malting properties are given and discussed. The total effects on the general malting quality, as a combination of all properties, are noted.

Effect of Date of Seeding

It has been shown (2) that, on the average (but with the exception of Swan River) delayed seeding caused progressive reduction in yield and malting quality (1). For convenience of comparison, data for grain yield and malting quality, showing the effects of delayed seeding, are shown as histograms in Figure 1. The left hand section presents the data for yield, the centre section for percentage heavy kernels and that on the right for percentage malt extract. The rows of histograms represent the data for each station and the means over all stations. Each individual histogram consists of columns representing the three dates of seeding, with the dates shown consecutively from left to right. The histograms for grain yield represent the mean values over the 3-year period, 1937–1939, and those for percentage heavy kernels and malt extract represent the results obtained from the 1938 crop. It has been shown (1, 2) that although some minor variations from the average trends exist within individual years, the average values over the 3-year period present a reliable measure of the effect of date of seeding on yield of grain, and that the malting data for the 1938 crop are typical of the effects of date of seeding on malting quality.

The bottom row of histograms shows clearly that, on the average, decreases in percentage heavy grade kernels and malt extract, and thus in malting quality, accompanied the decreases in grain yield brought about by delayed seeding. The decreases in malt extract are not as great as the decreases in yield, but they are none the less striking. Yields may be decreased to zero, but malt extract may be decreased only to a minimum figure of about 65%. The decreases in malt extract caused by delayed seeding are therefore relatively large in proportion to the possible range. Moreover, barleys producing malt extract lower than about 73% are actually unsuitable for commercial malting in Canada. The value of

barleys with a malt extract content lower than 73% is actually zero from the malting viewpoint. It is therefore clear that only barley from the first date of seeding was fit for malting.

Comparison of the results within the different stations shows that the factors influencing yield and malting quality are similar, though not identical. At Winnipeg, Carman, and Newdale, progressively later seedings caused progressive decreases in yield and malting quality. The greatest range in both yield and malting quality was produced at Carman, and the

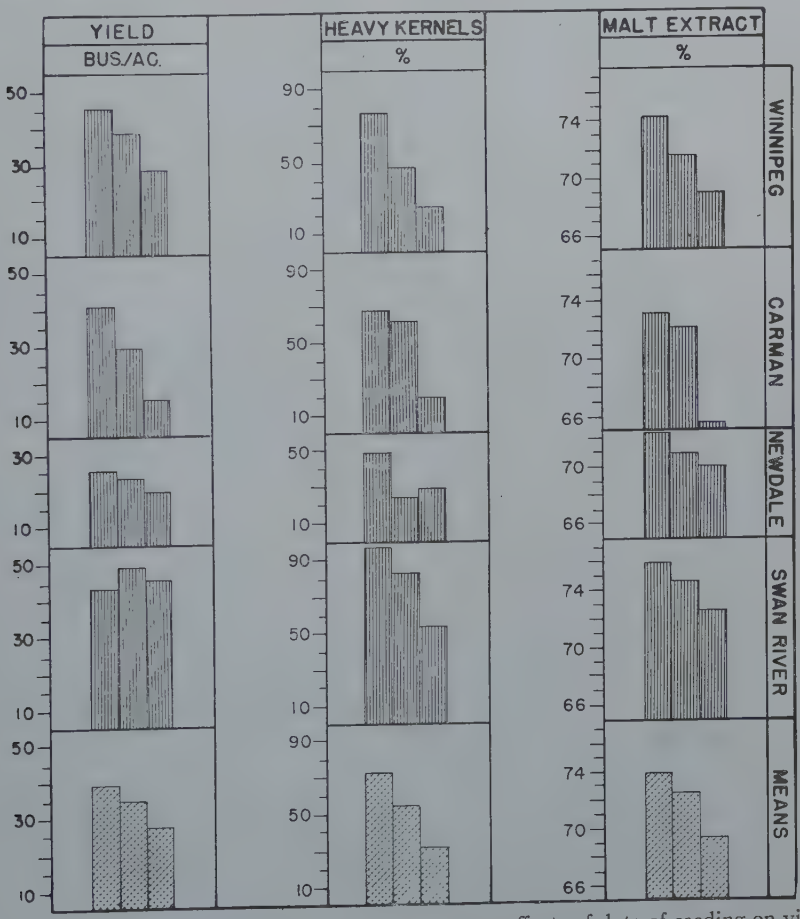

FIGURE 1. Histograms illustrating the average effects of date of seeding on yield percentage heavy kernels and malt extract at four stations. The columns in each histogram represent three consecutive dates of seeding, starting at the left with the first.

smallest at Newdale. At Swan River, however, the effects of delayed seeding on yield and malting quality were not the same. The highest average yield was obtained from the second date of seeding and the lowest from the first, and there were progressive decreases in malting quality from the first to the third date. However, it has been noted (2) that recommendations applicable to the central part of Manitoba would not apply to the Swan River district. In fact, owing to variability between

years with respect to optimum seeding date for grain yield, it does not appear possible to make specific recommendations for Swan River except that early seeding favours the production of barley of high quality. It may therefore be concluded that, for the greater part of the province of Manitoba, seeding about May 1st favours the production of high yields of barley of good quality. Even in the Swan River area, where the optimum seeding date for yield may be later in the year, but not necessarily later in the season, than the rest of the province, early seeding is advisable for the production of malting barley.

Differences between Gartons and the other two varieties, O.A.C. 21 and Mensury Ottawa 60, in both yield and malting quality were observed (1, 2). It was noted, furthermore, that these differences were reversed with delayed seeding. In general, at the first date of seeding the three

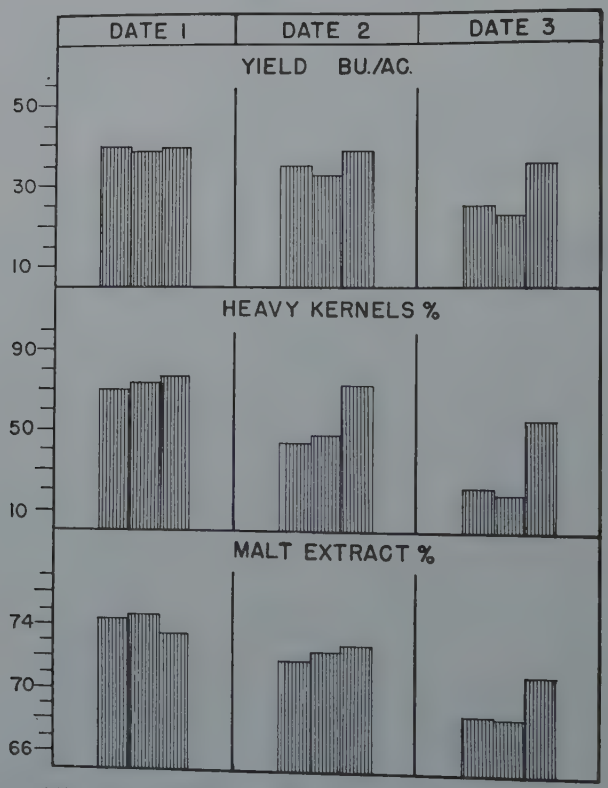

FIGURE 2. Histograms illustrating the differential effect of dates of seeding on three varieties, as means over four stations, with respect to yield, percentage heavy kernels and malt extract. From left to right the varieties are O.A.C. 21, Mensury Ottawa 60 and Gartons.

varieties were about equal in yield; at the second date Gartons tended to outyield O.A.C. 21 and Mensury Ottawa 60 (which were practically identical in behaviour throughout), and under the latest seeding Gartons outyielded O.A.C. 21 and Mensury Ottawa 60 by wide margins, as shown in Figure 2. The values represented pictorially in Figure 2 are the means for all stations, showing the effects of date of seeding on varietal position with respect to

yield, percentage of heavy kernels, and malt extract. The means were derived in the same way as those shown in Figure 1. With respect to malting quality, there is no doubt that when the first date of seeding is considered, Gartons was distinctly inferior to O.A.C. 21 and Mensury Ottawa 60. Only barley from the first date of seeding was fit for malting, so that varietal comparisons at other dates have no practical importance from the malting viewpoint.

Comparisons of the three varieties with respect to yield and malting quality within the first date of seeding are given in Figure 3 by means of histograms. The values are derived in the same way as those shown in Figure 1, the yields being shown as means for the 3-year period and the nitrogen content and malt extract as means for 1938 only. The left hand section presents the data for grain yield, the centre section the data for barley nitrogen content and the right hand section the data for malt extract. The rows of histograms represent the data for each station and the means for all stations. Each individual histogram consists of columns representing the three varieties. From left to right these are O.A.C. 21, Mensury Ottawa 60 and Gartons. The mean values for all stations, shown in the bottom row of histograms, indicate that there were actually only small differences between the varieties with respect to grain yield at the first seeding date. However, there is no doubt that Gartons was inferior to O.A.C. 21 and Mensury Ottawa 60 in malting quality, as shown by its higher barley nitrogen content and lower percentage of malt extract. With respect to malting quality, and in particular nitrogen content, the differences between Gartons and the other varieties are much more consistent than the differences in grain yield, as is evident from comparisons of the histograms for the individual stations.

The data illustrated in Figures 1, 2, and 3 are summaries of the information on the effects of date of seeding and variety on grain yield and malting quality obtained from tests conducted over a period of several years. It may be concluded that, for optimum production of malting barley, seeding as early in May as possible is necessary; and that O.A.C. 21 or Mensury Ottawa 60 should be sown. Delayed seeding reduces yield and quality, and high class barley cannot be obtained from late seeded crops. Of the three varieties studied, Gartons showed smaller decreases in yield due to delayed seeding than the other varieties, and this variety may be recommended when late seeding is unavoidable. It should be noted, however, that Gartons is not suitable for malting. The ability of Gartons to maintain fair yields over a range of seeding dates may be due in part to its tendency towards resistance to stem rust, but this does not account for all its differences from the other varieties. In this connection it is of interest to note that early seeded crops of O.A.C. 21 and Mensury Ottawa 60 were not seriously damaged by stem rust even in years with heavy rust epidemics. Early seeding is therefore necessary for at least three major reasons: 1. in order to produce high yields; 2. in order to produce high quality barley; and 3. in order to minimize the reduction in yield and quality in rust epidemic years.

Effect of Fertilizer Treatment

The effect of fertilizer treatment, as noted in previous papers (1, 3) differed at the different stations and with the different varieties. It was

also noted (3) that with respect to grain yield the optimum results from the application of fertilizer, within stations, were obtained at the optimum date of seeding. The average increase in yield, due to fertilizer treatment, for each station, was Swan River, 11.0 bushels; Winnipeg, 2.0 bushels; Newdale, 3.0 bushels; and Carman, 6.9 bushels. As shown in Part II (3) the two rates of fertilizer application that were tested were similar in effect, as there were only small differences between the increases in yield brought about by the two rates of application. It may therefore be concluded that the heavy application of fertilizer was not profitable at any of the stations.

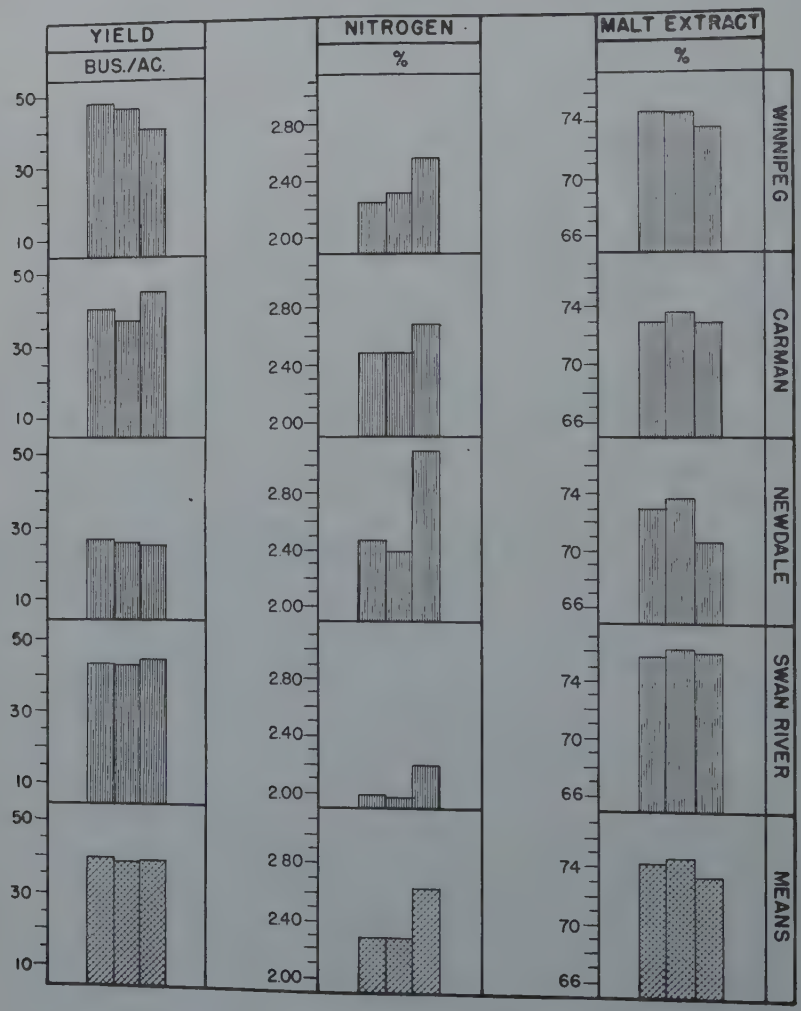

FIGURE 3. Histograms showing comparisons of three varieties at the first date of seeding at four stations with respect to yield, nitrogen content and malt extract. From left to right the varieties are O.A.C. 21, Mensury Ottawa 60 and Gartons.

However, the light rate of fertilizer application may be considered to have been profitable, on the average, at Carman and Swan River. It is doubtful just how far these results may be applied to other conditions, as the crops

were sown on summerfallow. It may be possible that greater responses to fertilizer would have been obtained had the crops been sown on stubble. It is also possible, however, that the reverse would have been the case.

As it was observed that the varieties reacted differently to fertilizer application, and that the effects of fertilizer application differed at different dates, it will be of interest to determine the conditions under which fertilizer brought about profitable increase in yield. This may be done by examination of the data in Table 1. This table is part of Table 5 in Part II (3), and gives the increase in bushels per acre caused by application of fertilizer, for each variety, at each seeding date, at each station. These results are the means for the 3-year period. Having shown that the heavy rate of fertilizer application was not profitable, the discussion is confined to the value of the light rate of application. For convenience in calculation barley is assumed to be worth 30 cents per bushel at the farm[4], so that O.A.C. 21 and Mensury Ottawa 60 are assumed to be worth 35 cents, owing to malting premium, and Gartons worth 30 cents. These values are low considering the price of barley for the past year and the premium for malting barley which has been a minimum of 8 cents per bushel for the last year, but they are probably fair averages for the past few years. The cost of the light application of fertilizer is assessed at $1.10 per acre.[5]

TABLE 1.—EFFECT OF FERTILIZER ON YIELD. DIFFERENCE, IN BUSHELS PER ACRE, BETWEEN TREATED AND UNTREATED PLOTS*

Station	Variety	Date 1	Date 2	Date 3	Mean
Winnipeg	O.A.C. 21	6.6	1.9	1.8	3.4
	Mensury	3.3	3.3	3.3	3.3
	Gartons	0.9	−2.0	−0.9	−0.7
Carman	O.A.C. 21	14.2	4.5	6.1	8.3
	Mensury	12.7	5.1	4.5	7.4
	Gartons	6.7	2.8	5.3	4.9
Newdale	O.A.C. 21	4.8	2.1	2.9	3.3
	Mensury	5.0	3.0	4.5	4.2
	Gartons	2.3	0.7	1.1	1.4
Swan River	O.A.C. 21	13.4	19.3	5.3	12.7
	Mensury	17.1	21.4	5.6	14.7
	Gartons	5.5	12.0	−0.3	5.7
Mean	O.A.C. 21	9.8	7.0	4.0	6.9
	Mensury	9.5	8.2	4.5	7.4
	Gartons	3.8	3.4	1.3	2.8

* Values for untreated plots subtracted from those for treated plots.

[4] Yearly average cash price, basis No. 3 Extra C.W. Six-row and No. 2 C.W. Six-row barley, in store Fort William-Port Arthur:

Crop Year	Grade	Price, cents
1936–37	No. 3 Extra C.W. Six-row	89.5
1937–38	No. 3 Extra C.W. Six-row	59.2
1938–39	No. 3 Extra C.W. Six-row	38.1
1939–40	No. 2 C.W. Six-row	45.6
1940–41	No. 2 C.W. Six-row	43.3

[5] Cost of fertilizer alone, as it was sown in drills at the time of seeding.

Out of the 12 values for each variety for the effect of fertilizer treatment in Table 1, 8 for O.A.C. 21, 11 for Mensury Ottawa 60, and only 4 for Gartons were actually profitable. On the average, the increases in yield for Gartons were only about half as great as those for the other varieties. It may also be noted that, at Winnipeg, Carman, and Newdale, the application of fertilizer was most profitable at the first date of seeding. At Swan River the greatest profit was obtained from the second seeding date, though the increases from the first date were also large and profitable.

The average effects of fertilizer treatment on malting quality may be noted from the bottom line in Table 2, which gives, as means for all stations and varieties, the differences between the fertilized and unfertilized crops (fertilized crop values used as base) for each date of seeding. It may be noted that the percentage of heavy grade barley was affected by application of fertilizer to a greater extent than any other property. Further, the effect of fertilizer was beneficial. It may also be noted that Gartons did not react in the same way to fertilizer as did O.A.C. 21 and Mensury Ottawa 60. As shown in the upper section of Table 2 O.A.C. 21 and Mensury Ottawa 60, in general, produced increases in percentage of heavy kernels and malt extract with application of fertilizer, while Gartons showed decreases in these properties.

TABLE 2.—EFFECT OF FERTILIZER ON MALTING QUALITY. DIFFERENCE BETWEEN TREATED AND UNTREATED PLOTS*

Variety	Nitrogen, %				Heavy, %				Extract, %			
	Date				Date				Date			
	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
O.A.C. 21	.04	.01	.01	.02	11.9	8.0	3.4	7.7	0.3	0	1.4	0.6
Mensury	.04	.04	.03	.04	12.4	6.7	4.9	8.0	0.4	−0.1	1.2	0.6
Gartons	.05	0	−.03	.01	−1.9	−2.5	3.5	−0.4	−0.3	−0.4	0	−0.2
Mean	.04	.02	0	.02	7.5	4.0	4.0	5.1	0.1	−0.2	0.9	0.3

* Values for untreated plots subtracted from those for treated plots.

Comparison of Table 2 with the bottom section of Table 1 indicates that where grain yield was profitably increased by application of fertilizer the malting properties of the crops were improved, and where fertilizer was not profitable from the yield standpoint it decreased malting quality.

It may therefore be suggested that the application of fertilizer at the optimum seeding date would be profitable in some areas from the grain yield viewpoint, and would tend to improve the malting quality of O.A.C. 21 and Mensury Ottawa 60, but would not be profitable for Gartons. It should be emphasized that the most important factor in successful barley culture, aside from variety, is date of seeding, and application of fertilizer will not make up for late seeding though it may still produce a profitable return under some conditions.

Effect of Rate of Seeding

Of the three rates of seeding that were compared, the medium rate ($1\frac{3}{4}$ bushels per acre) proved to be the most satisfactory with respect to

yield of grain (3). The heavy rate ($2\frac{1}{2}$ bushels per acre) produced only slightly greater yields than those from the medium rate at all stations, though there were considerable differences between the medium and light rates. The average yields for each rate, at each station over the 3-year period, are given in the left hand section of Table 3. The centre section gives the results for percentage of heavy kernels and the right hand section gives the results for nitrogen content, for 1938, of the crops from each seeding rate. On the whole, there were no great differences with respect to malting quality between the crops from the different rates of seeding. However, it appears that the heavy rate of seeding was least satisfactory for the production of malting barley. The crops from the heavy rate were highest in nitrogen content at two stations, Winnipeg and Swan River, and lowest in percentage of heavy kernels at the other two stations.

TABLE 3.—EFFECT OF RATE OF SEEDING ON MALTING QUALITY

Station	Yield, bus./ac.			Heavy, %			Nitrogen, %		
	Rate*			Rate*			Rate*		
	1	$1\frac{3}{4}$	$2\frac{1}{2}$	1	$1\frac{3}{4}$	$2\frac{1}{2}$	1	$1\frac{3}{4}$	$2\frac{1}{2}$
Winnipeg	34.8	38.3	39.6	48.9	49.7	51.1	2.39	2.41	2.51
Carman	26.2	29.0	31.0	48.9	52.2	48.3	2.64	2.63	2.64
Newdale	20.8	22.9	24.1	35.9	33.5	30.5	2.65	2.63	2.63
Swan River	42.7	47.3	48.7	75.5	77.3	77.2	2.09	2.09	2.16
Mean	31.1	34.4	35.8	52.3	53.2	51.8	2.44	2.44	2.49

* Bushels per acre.

Gartons showed differences from the other varieties in reaction to change in rates of seeding with respect to both yield and percentage of heavy grade kernels. O.A.C. 21 and Mensury Ottawa 60 were more sensitive to changes in rate of seeding with respect to yield than Gartons (3), and Gartons produced its highest percentage of heavy kernels from the light rate of seeding, while the medium rate was optimum for the other varieties (1). These differences between the varieties are of no practical importance in the production of malting barley, as only O.A.C. 21 and Mensury Ottawa 60 should be sown in Manitoba, but they may be of interest to those who, for various reasons, wish to sow Gartons.

For the production of optimum yield and malting quality it therefore appears advisable to sow O.A.C. 21 and Mensury Ottawa 60 at about $1\frac{3}{4}$ bushels per acre.

CONCLUSIONS

Agronomic investigations were carried out on three varieties of barley in 1937, 1938 and 1939, with the object of determining the optimum cultural practices (date of seeding, rate of fertilizer and rate of seeding) for the production of barley in Manitoba. Malting tests were made on samples representing the 1937 and 1938 crops. It is concluded that:

1. O.A.C. 21 and Mensury Ottawa 60 must be sown if the object is the production of malting barley. With early seeding no variety of the three tested can be recommended over the others on a yield basis, though

O.A.C. 21 and Mensury Ottawa 60 do tend to outyield Gartons under such conditions. If seeding were delayed the chances of obtaining malting barley would be forfeited and Gartons would return higher yields than the other varieties.

2. Seeding as early as possible is necessary to ensure optimum yields. Early May seeding is advisable for the major portion of Manitoba and a somewhat later date is advisable for northern districts, such as the Swan River area. Early seeding is also advantageous in that the danger of rust damage is reduced. Optimum malting quality is also obtained by seeding early.

3. A medium rate of seeding ($1\frac{3}{4}$ bushels per acre) appears optimum for both yield and malting quality.

4. A heavy application of fertilizer (96 lbs. per acre) is not profitable, but in some areas a light rate (40 lbs. per acre) may be profitable from the yield viewpoint and the malting quality of the barley would not be affected to any great extent. O.A.C. 21 and Mensury Ottawa 60 are likely to respond to fertilizer to a greater extent than Gartons would.

ACKNOWLEDGMENTS

The authors, who carried out the investigations at the request of the National Barley Committee, are indebted to the United Grain Growers Limited, the Canada Malting Company and the Dominion Malting Company for generous financial assistance. Encouragement and assistance during the course of the investigations from Dr. G. P. McRostie, Professor T. J. Harrison, Dr. C. H. Goulden, Dr. J. Ansel Anderson, Mr. P. R. Cowan and Dr. H. R. Sallans are gratefully acknowledged, as is the assistance during the field trials and malting tests of the co-authors of the previous papers in this series and of Mr. F. T. Cuddy, Mr. M. J. Sym and Mr. R. E. Bettner.

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THE EFFECT OF GREEN CROPS AND MANURIAL TREATMENTS IN RASPBERRIES[1]

J. J. Woods[2]

Commercial production of Cuthbert raspberries in the lower Fraser Valley in British Columbia commenced around 1895. The industry grew steadily for the next 15 years, and remained more or less stationary until 1919 when there was again rapid expansion due largely to soldier settlement. Up until 1920 there were practically no production problems as plants were vigorous, hardy and prolific. Most of the new plantings were set out on newly cleared land, a soil condition which many times has been proved almost ideal for raspberries and strawberries. During the decade 1921 to 1930 there were many clear indications that berry production was no longer as satisfactory as it had been in previous times.

Numerous theories were advanced for this condition. A possible explanation, especially on the older farms, was the decline of organic matter, and the physical condition of the soil brought about by long intensive periods of clean cultivation without the use of barnyard manure. During the period 1930 to 1940, the writer, while stationed at the Agassiz Experimental Farm, was closely associated with raspberry work in the lower Fraser Valley and studied many angles of raspberry growing. While at Agassiz, he directed an experiment designed to study the effect of green manure crops as compared to the use of barnyard manure, commercial fertilizer, and clean cultivation. It may be stated at the outset that results in subsequent years showed the location of the Agassiz Experimental Farm to be marginal in so far as the Cuthbert variety is concerned because of frequent winter injury from sudden changes in temperature, from relatively mild to below freezing accompanied by high, drying winds. Winter injury has caused a great deal of fluctuation in yields. It is reasonable to assume that under more favourable conditions yield data would be of a different order from that presented in the remarks and tables which follow.

The experiment laid down in 1930 consisted of the following treatments: cover crops spring seeded, were rye, crimson clover and vetch; these were compared to plot areas treated with barnyard manure at 12½ tons per acre, commercial fertilizer 5-10-6 formula applied at 750 lb. per acre, and clean cultivation. Plots consisted of two adjacent 50-foot rows, replicated for times in randomized blocks. All manurial applications were made in the early spring throughout the period of the experiment and the cover crops were ploughed down in June or July. Plots designated as clover have, during the past ten years, been cover cropped with the following: crimson clover, field peas, soybeans and lupines. The last mentioned, because of a variety of cultural factors, is considered a more suitable legume than the other kinds mentioned. The soil under which these tests were conducted is described in the Soil Survey of the Lower Fraser Valley as a Monroe Clay Loam, a type known to produce good raspberry

[1] Paper read at the Horticultural Group meetings of the Canadian Society of Technical Agriculturists at the Annual Meeting at Olds, Alberta, June 18-19, 1942.

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crops. The dominant type of soil for berry production in the Fraser Valley is, however, a Lynden Silt Loam, a lighter, more friable soil than the clay series.

Table 1 gives the total yearly yield for each treatment.

TABLE 1.—RASPBERRY COVER CROP EXPERIMENT—TOTAL YIELD BY YEARS AND TREATMENTS

Year	Rye	Lupine	Vetch	Manure	Fertilizer	Clean cultivation	Total
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1931	90.2	101.0	93.7	93.0	101.2	98.4	577.5
1932	233.2	236.6	240.7	239.6	222.6	296.1	1,468.8
1933	78.5	77.5	86.7	14.8	11.6	55.7	324.8
1934	151.1	126.2	135.7	91.1	74.9	127.1	706.1
1935	98.8	75.4	98.7	86.2	86.3	106.0	551.4
1936	249.4	164.6	167.2	132.1	61.3	220.3	994.9
1937	129.1	118.2	89.5	98.7	51.4	93.5	580.4
1938	97.1	83.2	63.1	59.7	46.9	78.7	428.7
1939	140.9	167.1	117.7	137.6	143.0	133.3	839.6
1940	117.2	129.4	101.0	107.3	199.8	142.0	796.7
1941	78.0	72.8	70.4	56.6	83.2	72.6	433.6
Total	1,463.5	1,352.0	1,264.4	1,116.7	1,082.2	1,423.7	7,702.5
Mean	133.0	122.9	114.9	101.5	98.4	129.4	—

Data from the annual yield tables are not submitted here but are significant as follows. There were no significant differences between any treatments in 1932, 1935, 1937, 1938, 1939 and 1941. In the other years there were significant differences as follows: in 1933 manure and fertilizer were significantly lower than all other treatments; all three cover crops were significant over clean cultivation but there was no difference between them; the significant difference required between means is 5.86 lbs. In 1934, manure and fertilizer were significantly lower than all other treatments; rye was slightly significant over clover and clean cultivation; the required difference between means is 5.80 lbs. In 1936 all treatments were significant over fertilizer and manure; rye was significant over all other treatments; clean cultivation was significant over clover and vetch; the difference required between means was 6.50 lbs. (The plot yield data for 1931 and 1940 were not available at this office at the time of writing and are, therefore, not included). The varying results between years has been due to weather conditions, particularly as it relates to winter injury.

The low yields in 1933 were due to severe winter injury, and in 1935 to canes being broken down by an ice storm and in 1938 to winter injury, but an appreciable amount of winter injury has occurred each year. Manure and fertilizer plot yields were particularly low in 1933. Fertilizer plot yields over the whole period averaged the lowest but showed a marked ability to rise following mild winters as in 1932, 1939 and 1940. Application of fertilizer increased growth more than any other treatment but induced succulent tissue which killed easily. On the other hand cover crops curtailed growth resulting in hardier wood. Table 2 gives the yield of woody growth produced in five representative years and indicates the effect of treatment on growth.

TABLE 2.—TOTAL ANNUAL WOODY GROWTH FOR 5 REPRESENTATIVE TREATMENTS

Year	Rye	Clover	Vetch	Manure	Fertilizer	Clean cult.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1931	124.5	124.5	131.0	148.5	162.5	162.0
1933	58.1	45.6	52.9	38.0*	32.7*	53.9
1938	55.7	58.6	48.3	86.1	89.4	60.1
1939	93.0	119.6	93.6	149.6	181.9	116.3
1940	66.3	67.7	79.5	89.5	115.8	78.9
Total	397.6	416.0	405.3	511.7	582.3	471.2

* Poor growth due to crown injury from winter 1932-33.

A comparison of yields of fruit and wood in Tables 1 and 2 show a reverse relationship. One is led to surmise that under more favourable conditions, that is, less winter injury and hardier varieties, manurial and fertilizer treatments with increased growth would show to greater advantage in yield of fruit.

In November, 1940, after ten years of manurial treatment, composite soil samples were taken from each plot area. Each composite sample was made up from four soil cores taken at a depth of 6 inches. A portion of each composite was placed in a 4-inch lacquered tin, 24 in all, and sunflower seeds were planted in each pot under greenhouse conditions. Some time after germination each pot was thinned to 3 plants and these were grown until terminal flower buds showed development on February 11, at which time all growth above ground was carefully harvested and weighed and the data were analyzed as representing a randomized block. The only difference obtained was that manured plots showed significance over all other treatments at the 1% level. In gram units, differences at 1% had to be 4·06 grams and at 5%, 2.94. Under the conditions of this experiment and by the pot method of measuring soil fertility cover cropping has not had a beneficial effect over clean cultivation.

Portions of the composite samples referred to in the above paragraph were submitted to the Division of Chemistry, Science Service, Ottawa, for determinations of nitrogen, organic matter and moisture-holding equivalent. Nitrogen was determined by the Kjeldahl method, organic matter by loss on ignition, and moisture equivalent by adding water to 100 grams of air-dried soil in a funnel until a drop percolated through the filter paper. Determinations with the exception of organic matter were made in duplicate.

The means for percentage nitrogen air dry basis for the six treatments are as follows: rye 0.195, clover 0.206, vetch 0.209, manure 0.241, fertilizer 0.200, cultivation 0.200. The complete data analyzed show a required difference between means at the 5% level to be 0.020 grams. Manure plots show differences between 0.030 to 0.046 over other treatments and it is the only instance in which there is significance. The increased nitrogen in manure plots was manifested in the greenhouse sunflower pot test referred to above.

Means for the organic matter determinations, percentage loss on ignition are as follows: rye 6.91, clover 6.98, vetch 7.02, manure 7.87, fertilizer 6.95, cultivation 6.91. The complete data analyzed show a required difference between means at the 5% level to be 0.70 grams. Manure plots show differences between 0.85 to 0.96 grams over other treatments and it is the only instance in which there is a significance.

Means for the moisture determinations are as follows: rye 29.8, clover 29.8, vetch 30.8, manure 31.2, fertilizer 30.6, cultivation 30.4. The complete data analyzed show a required difference of 1.60 for significance, the largest difference is 1.40 the results are therefore of a negative nature but manure shows the highest mean. Moisture determinations cannot be made with the precision of such analyses as nitrogen and organic matter. In the duplicate determinations there were variations up to one. While the evidence indicates an advantage for manure plots, it cannot be considered that the small differences obtained would have a practical value on plant growth.

CONCLUSIONS

The results of ten years cover cropping and manurial practices have revealed the fact that climatic conditions have influenced very markedly the cropping results.

Applications of fertilizer and manure have increased growth more than any other treatment (Table 2) but this increase in growth has not resulted in increased yields of fruit (Table 1) due to winter injury. Under conditions of this experiment the total of long term yields favours rye cover crops and clean cultivation. In six of nine years for which data have been analyzed there were no significant differences between treatments. In the three years for which there were significant differences, manure and fertilizer plots were excelled by all other treatments. Under more favourable growing conditions (less winter injury) it is assumed that applications of manure and fertilizer would have proved the most satisfactory.

Cover crops have not proved beneficial except that they have curtailed growth and enabled the canes to winter with less injury which has been reflected in larger yields. (This experiment has now been modified to include a combination of cover crops plus fertilizer).

Cover crops have not increased the nitrogen or organic content of the soil over clean cultivation. Manure has increased these values over all other treatments and may, therefore, be considered the best soil treatment. Moisture-holding capacity of the soil has not been significantly influenced by any treatment.

Cover crops, in spite of the fact that liberal amounts of growth were turned down each year, have not produced results often claimed for them.

ACKNOWLEDGMENTS

The writer is indebted to Mr. Bruce Dickson, Experimental Station, Saanichton, for analysis of the data presented, to the Chemistry Division, Science Service, Ottawa, for nitrogen organic and moisture equivalent determinations, and to Mr. W. H. Hicks, Superintendent Experimental Farm, Agassiz, for permission to present these findings.